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LONG-RANGE DEVELOPMENT PLANNING IN THE AIR FORCE.(U)

SEP 76 W E SIMONS, G K SMITH, E S OJDANA F44620-73-C-0011

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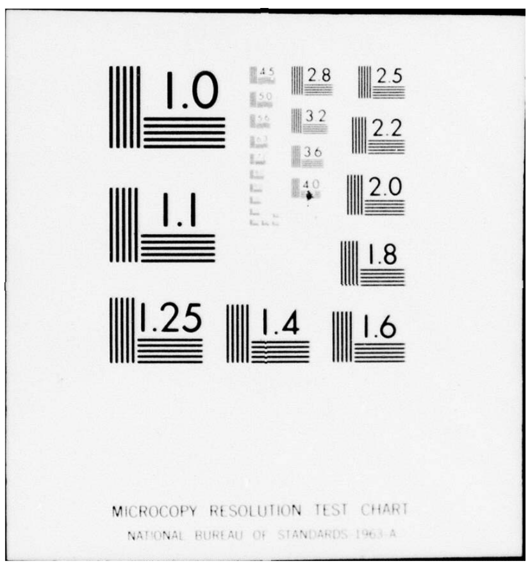
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# Long-Range Development Planning in the Air Force

W. E. Simons, G. K. Smith, E. S. Ojdana, Jr., R. Y. Pei,
S. W. Purnell, E. S. Wainstein



A report prepared for

UNITED STATES AIR FORCE PROJECT RAND



Rand
SANTA MONICA, CA. 90406

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~~A~~nalyzes current planning procedures in both the Air Staff and Air Force Systems Command and suggests ways of applying these procedures more effectively to technology development so as to enable the Air Force to develop the capabilities that it will need. Based on data from (1) the literature on management theory, industrial planning, and modeling techniques, and (2) interviews with government and corporate executives and planning staffs, current Air Force planning practices are examined critically in relation to an analogue developed from our theoretical study and supplemented by observations of industrial practice. Recommended improvements include establishing a systematic strategic planning effort by creating a small corporate planning staff within the Chief of Staff's personal staff, to be charged with exploring goals and alternatives suitable for the uncertainties of the future, with particular concern for resource constraints. Also, long-range corporate preferences with respect to resource allocation should be integrated routinely into RDT&E program planning at all levels. (See also R-1847-PR.) Bibliog. Glossary. (EFP).

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## PREFACE

This report presents the final results of Rand's Long-Range Development Planning study, undertaken at the request of the Air Force. In particular, the Air Force asked that we focus on finding better ways to determine what technologies should be pursued to develop the capabilities that will be needed in the future. Accordingly, the report analyzes current planning procedures in both the Air Staff and Air Force Systems Command and suggests ways for improving their contribution to effective technology development. A progress briefing of the study was presented to various Air Force offices in the summer of 1975.

The environment in which Air Force planning takes place may be undergoing fundamental change. New management control procedures and policies, some of them aimed at other Executive departments, are being imposed from outside the Department of Defense. Thus, procedures being developed in the Congressional Budget Office or the Office of Management and Budget may overtake some of the observations and evaluations reported in this study. Nevertheless, awareness of past practices and the interactions they produced may yield insights into organizational attitudes and preferences, and these should be useful to the Air Force in working within new departmental guidelines.

The study of long-range development-planning methods is part of a larger effort to study organizational, budgetary, and methodological issues affecting the efficient development and acquisition of Air Force weapon and support systems. Thus it is intended to complement work on such topics as life-cycle system costs, system-acquisition strategies, and methodologies for identifying system requirements. A detailed study of attempts to develop and use quantitative computer-based planning models for defense-related R&D, summarized briefly in this report, is presented separately in E. S. Ojdana, Jr., and J. P. Weyant, *An Assessment of Selected Models Used for Evaluating Military R&D Projects*, R-1847-PR, September 1976.

The long-range development planning study was requested by officials responsible for development planning in Hq USAF. In addition to being of interest to those with Air Force R&D planning responsibilities, the report should be useful to force planners and programmers and to DoD officials engaged in planning for any activity that relies on the products of technology for its future capabilities.

## CONTENTS

## SUMMARY

Several kinds of uncertainty are inherent in the process of planning technology programs intended to lead to operational and functional capabilities of the distant future. The kinds of uncertainties vary, depending on whether the development effort stems from a clear perception of a particular capability that is needed or from a general desire to exploit a promising area of technology. Moreover, as development proceeds the nature of the uncertainties will change. Environmental conditions that were hazy at the time of initial planning will have assumed clearer definition because of events that have occurred. or experimentation will have clarified previously unknown characteristics and performance limits.

In discussing the problems involved in making choices today regarding technology that will not have application until a distant tomorrow, some Air Force officials have expressed dissatisfaction with the way in which long-range interests have been integrated with short-term programming strategies, which pertain only to the next five years. In fact, there is a substantial feeling that the need for such integration is not being met very well at all. It is for this reason primarily that Rand was asked to undertake this study of possible improvements to Air Force development planning procedures.

In approaching this problem, we have focused our attention on Air Force Exploratory and Advanced Development efforts and have dealt with the following questions: To what extent does an effective technology development planning process exist in the Air Force today? What kind of improvements may be called for? To establish a basis for evaluating current Air Force R&D planning practices, we have sought three types of information:

- Organizational management theory
- Quantitative R&D planning models
- Industrial planning practices

Thus, our work began with a search of the literature on management theory, industrial planning activities, and modeling techniques. This research was complemented by visits to government offices and industrial corporations. During these visits, interviews were held with planning staff members and corporate executives, and with individuals who have utilized modeling techniques. Extensive interviews were conducted with participants in the Air Force's Research, Development, Testing, and Evaluation (RDT&E) planning and its related planning efforts. These included members of the R&D community on the Air Staff, in the Air Force Systems Command (AFSC), and in Defense Research and Engineering (DDR&E), Office of the Secretary of Defense. It also included participants in the force planning and programming activities within the Air Staff whose efforts contribute to the identification of capabilities toward which R&D can eventually lead. Our contacts with members of the Air Force R&D community were concentrated rather heavily among those on the headquarters planning staffs. Our exposure to Air Force laboratories, at which technology development is actually pursued (both in-house and through external contracts), was limited to a small sampling. We had no exposure in the field to the development activity under contract, supervised by the AFSC systems divisions.

Based on these data, current Air Force planning practices were examined critically in relation to an analogue developed from our theoretical study and supplemented by our observations of industrial practice. The analogue (Fig. 2, p. 17) distinguishes between strategic and functional planning and describes how the long-range goals, resource assessments, and corporate policies which result from strategic planning provide guidance for the setting of technology subgoals and the assessment of short-term technical alternatives during functional planning. Strategic planning, which focuses primarily on the organization's future relationship to the external world, tends to be analytical and speculative, and deals with unstructured, irregular problems and insufficient data; functional planning is oriented directly to the internal control functions affecting current programs, tends to rely on internally generated data, and takes place according to highly structured procedures and timetables. As a result of functional

planning, a set of recommended current resource allocations among selected technology program alternatives is produced.

Our observations of industrial planning practices enabled us to identify the following common elements that seem worthy of emulation by the Air Force:

- R&D planning, programming, and budgeting is separated from other corporate programming and budgeting activities.
- A small staff carries out corporate strategic planning for the organization's chief executive directly; a similar R&D planning staff serves the senior R&D executive.
- The organization's long-range goals are assessed frequently.
- R&D planning is structured, but quantitative methods are not widely used.

We found that <u>the central shortcoming in the Air Force's long-range technology development planning is the inadequate state of strategic planning in the Air Staff</u>. At present, only a limited variety of long-range operational and functional goals are identified, and by methods that are not appropriate for dealing with the uncertainties inherent in the long-range planning period. Resource limitations that will possibly be encountered in this distant time frame are not assessed in terms of their potential impacts on future programs. Moreover, <u>top management's views about the relative importance of different capability alternatives and program directions for the period under consideration are not communicated regularly to technology development planners</u>.

Functional RDT&E program planning for the Air Force 6.2 and 6.3 development categories has improved in several encouraging ways since we first undertook this study. Assisted by Headquarters AFSC's new analytical assessments of capability and technology requirements in each mission area, systematic efforts to develop better program goals have been instituted both for the laboratory and system-oriented

development efforts. Systematic comparison and evaluation of alternative technical approaches within respective mission areas are being accomplished by AFSC for the 6.3 program elements. Alternative patterns of 6.2 and 6.3 resource allocation to accommodate different overall program levels are being examined in the course of the annual RDT&E planning and programming activity.

Clearly, some technology, particularly some in the 6.2 category, cannot be linked directly to a particular operational capability, either present or future. Planning for some exploratory development work must be based heavily on intimate understanding of each field's physical phenomena and technical promise. Program planning efforts for other technologies are inhibited in what they can accomplish, however, by the inadequacies of Air Force strategic planning. Corporately endorsed strategic goals and policies are needed so that all parties to the extremely complex RDT&E planning and programming process can act from common recognition of where the Air Force thinks it should be heading.

As the process now operates, it is possible for each planning office, program review group, and reviewing authority to follow its own perceptions of what the future direction should be. Thus far, AFSC's development planners have been forced by circumstances to devote much of their effort to filling the gap left by the Air Force's inadequate strategic goal setting. But their goal statements are largely near term, not long range, in orientation and have only limited utility as guidance for laboratory planning efforts. Only recently have AFSC development planners been able to initiate efforts that are more appropriate for translating Air Force preferences regarding future capability objectives into guidance directly useful in determining program goals for different levels of technology. In terms of industrial practice, AFSC currently is attempting to accomplish the planning function of both a corporate planning staff and an organization's R&D planners. This functional imbalance is likely to continue as long as the Air Staff and Air Force top management fail to provide for regular corporate assessments of the organization's long-range

operational and functional goals and fail to provide functional planners with explicit statements of the organization's long-range policy preferences.

Our recommended improvements include establishing a systematic strategic planning effort by a small corporate planning staff located within the Chief of Staff's personal staff. This office would be charged with exploring goals and alternatives suitable for the uncertainties of the future, with particular concern for resource constraints likely to be encountered. The strategic planners would be encouraged to cast off the conceptual constraints of an orientation towards identifying replacement systems for the current mission areas and towards assuming that current command arrangements and institutions will be perpetuated. The yearly output of the corporate planning staff need not be comprehensive in the sense of covering all capability areas each year, but should provide inputs to such formal PPBS programming actions as that served by the Extended Planning Annex.

We also propose that Air Force top management should make known in a formal statement its preferences regarding long-range capability goals and the distribution of future resources. The Air Force Council and Air Force Policy Council should participate fully in this function. These preferences should be communicated to the functional staff elements, particularly those engaged in near-term force planning and RDT&E functional planning. It follows that long-range corporate preferences with respect to resource allocation should be integrated routinely into RDT&E program planning at both Headquarters AFSC and Air Staff and in planning accomplished by the Air Force laboratories. Control procedures implemented by the Air Staff R&D managers and by Headquarters AFSC should assure that the planning actions over which they exercise authority include careful attention to these long-range preferences.

## ACKNOWLEDGMENTS

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In addition, many Air Force officers cooperated generously in furnishing us information and useful insights; a few contributions warrant particular mention. Colonels K. D. Barnes, P. H. Caulfield, and A. Lavish and Lt. Col. M. S. Tavenner, of Headquarters AFSC, Colonel F. L. Young and Lt. Colonels J. G. Burton and C. E. Watts, of the Air Staff, each read earlier drafts and furnished valuable criticism. Their comments helped steer us away from oversimplifications and added greatly to our understanding of a complex process. The final judgments and evaluations--and any errors--in the report are our own.

# I. INTRODUCTION

> Q. Mr. President, since it is widely believed the Soviet Union has larger rockets capable of carrying heavier payloads and being MIRVed to a larger extent than our warheads, can you tell us what the relative position would be between the United States and the Soviet Union in terms of warheads if each side goes to the maximum number of 1,320 on the MIRV limit?
>
> A. Well, on delivery systems we are equal. On the MIRVing we are equal. I think the question you're asking is throw weight. It is recognized that the Soviet Union has a heavier throw weight but the agreement does not preclude the United States from increasing its throw weight capability.
>
> A number of years ago, our military decided that we wanted smaller missiles that were more accurate. . . . Now the throw weight problem is one that we can remedy if we want to. Our military took a different point of view some years ago when they designed our ballistic missiles. But we have flexibility. Now, if we decide to go to a heavier throw weight, we can add a . . . greater number of individual warheads. That's a choice--a flexibility that we have, and I think it's one of the benefits of the agreement.[1]

The preceding exchange illustrates how past policies and past planning decisions about weapon systems have affected current military capabilities. Today's decisions on today's military Research and Development (R&D) programs will have a similar impact on the nation's future military capabilities.

Obviously, all of the factors that will determine the ultimate wisdom of today's decisions about the development of future capabilities cannot clearly be foreseen. With MIRVs, planners opted for a more accurate missile at the expense of throw weight. A decision had to be made, even though there was much uncertainty about the eventual cost of the system, the technical feasibility of the concept, the

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[1] Excerpt from President Ford's press conference on December 2, 1974, commenting on strategic arms control proposals emerging from his meeting with Brezhnev in Vladivostok, *The New York Times*, December 3, 1974, p. 28.

strategic context in which it would operate, and the possible counter-strategy of our most likely opponent. Certainly, the emerging spirit of detente, the Strategic Arms Limitation Talks (SALT) negotiations, and the corresponding need for mutually verifiable capability gradients were not completely foreseen at the time this decision was made.

## UNCERTAINTIES IN R&D PLANNING

The example above illustrates the variety of uncertainties with which future-oriented R&D programs must cope. To develop capabilities that will be used in the distant future requires projections of user needs, estimates of operational conditions, and specifications of expected performance that are inherently uncertain.

Decisions about what kinds of capabilities to develop are based on a number of highly uncertain considerations: What will be our national strategy and how will our resources constrain its implementation? Who will be our opponents? Under what circumstances are we likely to confront them? What capabilities will they have?

Decisions about the kinds of intermediate technology development to undertake--about the kinds of technical building blocks that will need to be constructed en route to a useful capability--involve still more uncertainties. What kinds of options can technology make available now? In the near future? How predictable is the technical success of a particular option? Which options are being pursued by other developers? What new alternatives might success make available? What alternative budgetary and opportunity costs might be incurred to achieve assumed benefits through the choices now available?

Ultimately, as technology evolves and is combined into more complex hardware and systems, still other uncertainties predominate. What random variations may appear in system performance? What factors largely determining performance may prove to be immeasurable? What kind of measurement errors may creep into the system and thus affect performance and reliability estimates?

Uncertainty is an important dynamic in R&D and an important consideration for development planning. The nature of uncertainty will

change as technology development proceeds. Initial uncertainties may be reduced with the passage of time; knowledge acquired in the process of development will reduce other uncertainties. New discoveries may stimulate the pursuit of new goals and require the consideration of new development alternatives. New uncertainties may be encountered. One should expect R&D planning to take account of the various shifts in uncertainty and provide appropriate hedges (e.g., by preserving development options) as the different areas of technology develop from one stage to the next.

## PROGRAMMING IN R&D PLANNING

Planning for technology development that will lead to future Air Force capabilities encompasses the need to make hard-choice decisions regarding a wide range of current technology programs. Deciding what resources to allocate to specific programs during the next few years and in what increments is the essence of programming. Some programs are designed to explore the technical feasibility of new concepts. Some afford alternative hardware prototype development and testing. Other programs work out the detailed engineering of components and systems for possible quantity production.[2] Given perennial resource limitations, program decisions by their nature involve the elimination of certain alternatives. If those alternative lines of development are not available through some other source, their early elimination from the Air Force technology program could limit what is available at a more advanced level of development in future years. In effect, therefore, program decisions both constitute key elements of current planning and afford direction for follow-on planning.

It follows that an important element in long-range development planning is to give visibility to the possible technology and

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[2]These types correspond, respectively, to the Exploratory Development (6.2), Advanced Development (6.3), and Engineering Development (6.4) categories into which--along with Research (6.1) and Management and Support (6.5)--the Department of Defense's RDT&E program is currently divided. Research is concerned solely with general scientific research; the 6.5 category includes operation of the test ranges and support for the Federal Contract Research Centers (FCRCs).

resource-allocation consequences of current program alternatives. Where possible it is also important that their impacts on the attainment of future capabilities be assessed. This function affords an opportunity to determine appropriate hedges for the uncertainties characteristic of each type of development activity so that these hedges may be integrated into the periodic near-term development program decisions.

Problems arise with respect to this highly desirable process of integrating long-range hedging strategies with near-term program considerations. What is perceived by programmers (and especially budgeteers) as a good strategy for maximizing next year's budget may not appear compatible with a strategy which R&D planners perceive as needed to acquire a particular capability 10 to 15 years in the future. Neither may it be readily compatible with a strategy to encourage and exploit a promising technology in order to give visibility to a new array of capabilities.

So, despite all the attention given to the management and planning of R&D activities by other military services and industrial firms that compete on the basis of technical advancement, the search for better planning procedures continues. Dissatisfaction with the integration of long-range development and short-term programming strategies, we suspect, is in part what prompted the Air Force's request for this study. Much of the progress that has been made in understanding and improving the planning of R&D activity can be traced to the Air Force and the Department of Defense (DoD), yet the procedures used today are considered by some to be less than satisfying.

## SCOPE OF THE STUDY

This study examines how the U.S. Air Force currently conducts its technology planning and how Air Force procedures may be made more effective. It focuses exclusively on the procedures and mechanisms used in planning--on the *making* of planning decisions, not their content. Rather than addressing the question of whether the right kind of capabilities and technologies are being provided for the

future, the study considers whether or not an effective planning process exists and what kind of improvements may be called for.

Since we will not be concerned with the technical content of current Air Force R&D, the effectiveness of current planning procedures is not judged with reference to the technical merit of the development products. Rather, it is evaluated with reference to certain minimal administrative actions and qualitative assessments assumed to be essential parts of a rational planning process. The primary sources for these criteria are currently recognized management theory and observed industrial practice. Particularly useful as a basis for examining organizational planning procedures is the approach suggested by Robert Anthony of the Harvard Graduate School of Business.[3] In this approach distinctions are made between planning designed to set an organization's future course relative to the external world (strategic) and planning designed to facilitate managerial control over its internal processes (functional). These distinctions have been used throughout our study, first, to construct an idealized concept of long-range development planning (Chapter II) and, later, to provide an analytical framework against which current Air Force practice may be compared.

Being concerned primarily with long-range development planning, this study concentrates on only a part of the overall Air Force R&D program. In particular, it deals with technology development efforts (not research) whose expected products do not yet appear in any of the programming documents as specific inventory or scheduled equipment acquisitions. A fixed time limit cannot be placed on such a definition. Some hardware items move from the earliest development stages into the Air Force inventory in well under a decade, while most developments take longer. But generally, the study is concerned with technology development efforts that will take at least six, perhaps twelve or fifteen, years to yield results in terms of a new operational

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[3] In Robert N. Anthony, *Planning and Control Systems: A Framework for Analysis*, Harvard University Press, Cambridge, Mass., 1965. Anthony served as Assistant Secretary of Defense (Comptroller) from 1965 to 1968.

capability. This study does not address the planning for or development of major weapon systems programmed for the force in the near future or any R&D work done in direct support of existing operational systems.

How is one to label that portion of the current R&D spectrum dealt with in this study? For sake of convenience we shall refer throughout much of the report to Exploratory and Advanced Development, two of five program categories into which Defense R&D is subdivided in the Department's Planning, Programming, and Budgeting System. These two categories (PPBS categories 6.2 and 6.3) absorb almost one-third of the total Air Force RDT&E budget and represent the effort to explore feasible applications of basic research for possible full-scale development into useful military capabilities. They comprise the development aspects of the R&D program grouping which the current Director of Defense Research and Engineering has labeled "Creation and Demonstration of Options."[4]

Dr. Currie's aggregation of current R&D programs into different groupings may have been prompted in part by a shortcoming of the PPBS program categories. As presently constituted, these categories do not correspond directly to the different sets of planning criteria that are appropriate to different portions of the R&D program spectrum. Figure 1 depicts how the current range of Air Force RDT&E programs (shown by horizontal bars at the top) might be grouped by planning criteria. At the far right are the programs selected for full-scale system development and programmed into the force structure, e.g., the B-1 strategic bomber, the F-16 lightweight fighter, etc. For these programs, planning decisions are based on fairly specific cost, performance, and production schedule criteria; they are outside the scope of this study.

Everything to the left of the full-scale development grouping is, by our definition, within the purview of long-range development planning.

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[4] Dr. Malcolm R. Currie, Statement to the Senate Armed Services Committee, February 5, 1976 (mimeo), presented during hearings on the FY 1977 Authorization of Military Procurement and RDT&E. Dr. Currie classified all Defense RDT&E program elements into two groups: "Group One: Creation and Demonstration of Options," and "Group Two: Full-Scale System Development."

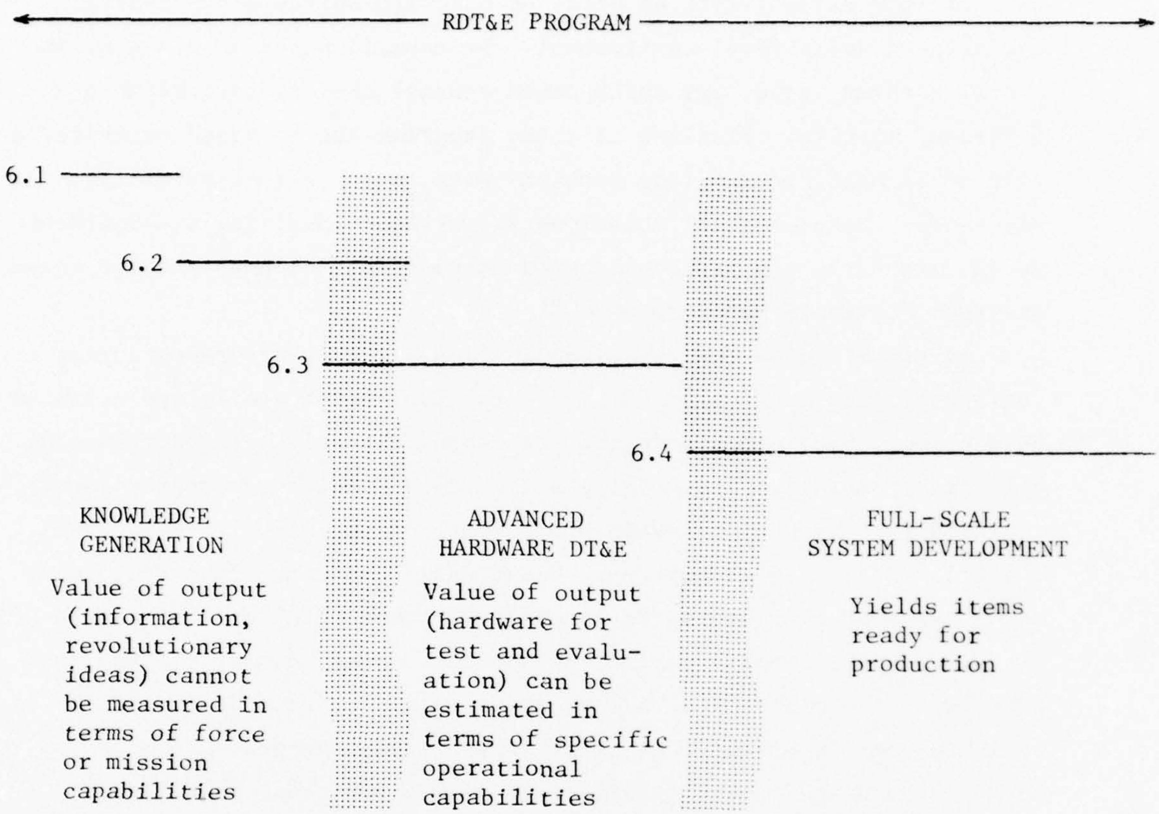


Fig. 1--R&D categories by planning criteria

But these programs may be divided further according to appropriate planning criteria. Those activities on the far left of Fig. 1 possess characteristics similar to research; they are phenomena-oriented. That is, their objectives involve greater understanding of their respective physical phenomena. The value of their products cannot be related directly to operational mission or supporting functional capabilities. One cannot measure their worth according to criteria of military utility and must plan projects largely on the basis of demonstrated technical promise and theoretical soundness. For identification purposes we have labeled these activities "knowledge generation."

By contrast, the programs in the center of Fig. 1 can be evaluated in terms of their expected impact on mission and functional capabilities.

Many of them yield a working piece of hardware suitable for testing in a simulated operational environment. An example might be a new or improved sensing technology which could enhance the accuracy of an air-to-ground missile. Planning of these programs can be based on criteria related to specific military problems with the object of providing alternative technological solutions but without involving a commitment to develop fully any particular production item. We have labeled these programs "advanced hardware DT&E."

As signified by the relative positions of the bars representing current program categories (Fig. 1), the Exploratory (6.2) and Advanced Development (6.3) efforts do not correspond directly with our planning criteria groupings. Practically all of the current 6.3 programs are included in "advanced hardware DT&E," but so are some of the 6.2 and a little of the 6.4 categories. Thus, while excluding research, this study pertains to planning for both development which can be related to future operational capabilities and that which cannot. In the report, when the planning of 6.2 programs is discussed, the text will indicate when important whether it is the knowledge-generation or advanced-hardware type of exploratory development that is being referred to.

## STRUCTURE OF THE REPORT

Air Force technology development is a complex enterprise. Not only do different planning criteria apply; different program categories are managed in somewhat different ways. For example, whereas Air Force Headquarters (Hq USAF) and Headquarters Air Force Systems Command (AFSC) participate meaningfully in the management of both the 6.2 and 6.3 programs, 6.2 management is uniquely affected by substantial areas of decision autonomy granted to the Air Force laboratory community. On the other hand, primarily due to the unusually larger budgets of their included projects, the 6.3 programs receive more attention from Congress as it authorizes and appropriates RDT&E funds.[5] The role of

[5] The unique features of the Air Force RDT&E program management will be described in detail in Chapter III.

Congress and its relationship to the overall budgeting system maintained for the Executive branch make military R&D management more complicated than the corresponding activity generated by private industry.

To analyze this administratively complex enterprise, our study employs a model of an idealized long-range development planning process. This model, described in Chapter II, links the setting of external capability goals for an uncertain future with the sorting out of technical and budgetary options for current technology programs, according to theoretical distinctions between strategic and functional planning. To be sure, our model probably is not fully adequate for evaluating planning which must be accomplished within the Department of Defense's overall management system. At least its adequacy will certainly vary in sharp degree as between the "knowledge generation" and "advanced hardware" portions of current development activity. Still, some fixed points of comparison are needed, and due regard is accorded in the text to those features of Air Force planning and programming practice which cannot properly be related to the idealized development planning concept.

Other bases for comparison are provided in Chapter II through reference to industrial planning practices and to the experiences of industry and governmental organizations in using quantitative planning models. Of course, however effective these methods may be in the civilian market economy, they may not provide valid instruments for the DoD setting. But industrial corporations have tried a number of planning approaches and have retained those systems and procedures which have proved most effective for their purposes. What these are and why they have been retained are described in Chapter II. The chapter also discusses some attempts to use quantitative planning models, certain of the techniques developed, and some of the problems encountered.

Current Air Force planning practices which approximate the development planning functions outlined earlier in the paper are described in Chapter III. The discussion includes both the planning actions engaged in by the Air Staff and those performed in Air Force Systems

Command. With respect to the Air Staff, both R&D planning and other forms having relevance for long-range development planning are considered. Throughout the discussion important distinctions between the procedures applying to 6.2 programs and those applying to 6.3 are explained.

In Chapter IV these current Air Force practices are analyzed in terms of our idealized long-range development planning model and civilian industrial planning practices. Shortcomings are pointed out in relation to these analogues. However, throughout the discussion, the kinds of uncertainties and constraints encountered, both in the strategic and functional planning phases, are identified and their real-world impacts acknowledged. Suggestions for improving the current approach to development planning are offered in the concluding chapter.

## II. TECHNOLOGY DEVELOPMENT PLANNING: THEORY AND PRACTICE

As implied earlier, technology development is motivated by two equally significant classes of imperatives: (1) nurturing and proving the technologies essential for providing a specified capability; (2) creating and exploiting technical opportunities to provide new kinds and levels of technology from which useful capabilities might be conceived. These imperatives have on occasion been referred to as "demand pull" and "supply push," respectively. Briefly put, the Air Force's development planning problem is to devise new or improve old planning procedures so that they will reflect both these imperatives and balance their respective influence on technology program decisions.

To a greater or lesser degree all industrial organizations face similar problems. Their managers must plan for the development of technologically new or improved products and services as well as for more apparently immediate concerns, including budget, facilities, production schedules, employment practices, and the like. Some of their experience can be instructive. Moreover, management-science literature contains a number of observations and principles which are helpful in understanding the basic functions of planning and in structuring an effective process. In particular, this literature has led to a number of efforts to construct quantitative R&D planning models and apply them to the management of defense or industrial R&D programs.

In this chapter all three types of explorations into better R&D planning--management theory, quantitative modeling, and industrial practice--are examined for features that may assist in analyzing development planning in the Air Force.

### A SCHEMATIC VIEW OF PLANNING

A survey of the management literature indicates little agreement on a single definition of planning,[1] but there is some consensus about

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[1]See the essay by Mabel T. Gragg, "'Planning' and 'Control,'" Anthony, op. cit., Appendix A, pp. 129-147.

two types of planning applicable to any organization. These two types of planning can be identified as "strategic" (sometimes referred to as "corporate" or "creative") and what we have labelled "functional" planning. There is a contrast between these two planning activities in terms of their objectives, data sources, timetables, and administration.

Strategic planning identifies the organization's relationship to the external world. It involves setting the organization's long-range goals and formulating policies that "determine or change [its] character or direction. . . ."[2] Based more on data and knowledge external to the organization than on information generated internally, strategic planning is usually accomplished by relatively few staff members, sometimes organized into a special staff unit, with active participation from top management.[3] By its very nature, strategic planning is likely to be applied to problems that are unstructured and irregular; decisions are likely to be based on uncertain and insufficient data and must therefore be arrived at through more creative and analytical mental processes.[4]

By contrast, functional planning deals more with the program objectives and methods developed internally to move the organization in the direction set by top management and is therefore closely integrated with the programming and management control processes of the organization. Management control relates to current operations and "is a process carried on within guidelines established by strategic planning. Decisions about next year's budget, for example, are constrained within prescribed policies and guidelines."[5] Based on data that are for the most part internally and regularly generated, planning associated with management control takes place according to highly structured

[2] Anthony, op. cit., p. 24.

[3] Line managers, as a rule, are not major participants in strategic planning except in those organizations with nearly autonomous divisions. In these cases, a division manager will engage in strategic planning for his division, ibid., p. 50.

[4] Ibid., pp. 10-16, 24-25, 43, 46, 50, passim.

[5] Ibid., pp. 31-32.

procedures and timetables, uses more accurate and reliable data, and is more routinely administrative in nature.

Although it is possible to separate these two forms of planning conceptually, they are often difficult to separate in practice. Moreover, both involve similar planning procedures: setting goals, assessing the resources available for achieving those goals, and formulating policies for the utilization of those resources. But, whereas strategic planning describes expected and preferred outcomes for the organization as a whole, functional planning is designed to lead to actions and to more precisely defined results in a particular area of that organization's operations. Thus, in addition to the above procedures, functional planning also includes the development of alternative programs whereby functional elements of the organization can achieve appropriate subgoals.

The setting and modification of goals play a vital part in planning throughout an organization. Ideally, according to classic theories, the goals developed at the top of an organization, i.e., through strategic planning, and those pursued by the functional elements of that organization will coincide. In a perfectly managed organization, these goals will be shared by various participants and conflict will be eliminated through consensus. In reality this is seldom the case. Studies suggest that organizational consensus usually exists only on highly ambiguous goals and that there is considerable disagreement and uncertainty within organizations about subgoals.

Moreover, organizational goals may actually reflect and respond to changes in the subgoals of the functional elements and of individuals. In this conception, organizational goals are arrived at through a continuous bargaining and learning process, and organization coalitions are assembled to support agreed goals. These coalitions are formed with the aid of some kind of side payments to participants--personal emoluments, awards of authority, or policy commitments. The potential dynamism resulting from individual subgoal changes is stabilized to manageable proportions through such control mechanisms as budgets and functional allocations.[6]

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[6]Richard M. Cyert and James G. March, *A Behavioral Theory of the Firm*, Prentice-Hall, Inc., Englewood Cliffs, N. J., 1963, pp. 28-38, passim.

This process occurs simultaneously with and may be considered a natural complement to management control. In pursuit of what has been called "goal congruence," a management control system will be effective if it encourages functional elements to plan actions in their perceived self-interest that are also in the best interests of the whole organization. To be effective a management control system must provide for free-flowing communication throughout the organization: (1) communication of the policies and priorities resulting from strategic planning to all the functional elements and (2) communication to top management and strategic planners of the subgoals and motivations which influence the functional elements.

## IDEALIZED DEVELOPMENT PLANNING

The pursuit of goal congruence is central to the problem of technology development planning. Highly dependent on individual creativity and initiative, R&D effort by its very nature cannot realistically be expected to pursue subgoals which mirror exactly organizational goals. At best, therefore, one can conceptualize a hierarchy of different stages of R&D activity where each stage is motivated by subgoals and alternative subgoals appropriate to the nature of the technical work being performed but is linked rationally with the other stages.[7] Different structures for such a hierarchy are reflected in the PPBS categories for the Defense RDT&E program and in the alternative sets of R&D planning criteria suggested in Chapter I.

Using the construct described in the preceding section, technology development planning involves seeking congruence between two basic types of goals: strategic and functional. The strategic goals appear in top management decisions about the kinds of product lines

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[7] This conception is similar to Simon's theory of purposive organizational behavior that is achieved through an imperfect hierarchy of decisions and goals. In his concept the rationality of a decision at each stage in organizational behavior is judged "insofar as it selects alternatives which are conducive to the achievement of the previously selected goals . . . each step downward in the hierarchy consisting of an implementation of the goals set forth in the steps immediately above." Herbert A. Simon, *Administrative Behavior*, The Free Press, N. Y., 1965, p. 5.

or (in military organizations) operational capabilities to pursue. Functional goals include the specific technologies which need to be developed in different program stages to fabricate eventually a particular kind of product or a specified capability. They also include the incremental technical and phenomena-oriented milestones which must be reached if a promising technology is to be developed to the point where its possible applications to a product line can be evaluated.

Technology and other subgoals should reflect the organization's strategic goals and preferences, assuming that these goals and preferences are arrived at in full awareness of the state of the art and the technology programming realities that determine their feasibility. This means that those who are responsible for the planning of current technology development at all levels must be fully aware of the organization's view of the future. Another means of encouraging goal congruence would be a provision for periodic review of the technology subgoals by corporate management.

Of course, technology development planning involves more than simply selecting goals. Consideration must also be given to resource availability and the policies to be observed in utilizing resources. In the realm of strategic planning, different degrees and kinds of resource limitations that might be encouraged in the future need to be assessed. It would be quite risky to use future product goals as a guide to current technology work without considering the durability of current technical barriers, the availability of essential development facilities, and the prospects for continued funding support. It is essential, moreover, that the kinds of uncertainty likely to be encountered in progress toward a desired product be anticipated.

In view of such considerations, strategic planning for development should culminate in determination of a sense of priorities among the array of future capabilities which an unconstrained organization might otherwise wish to pursue. These policy decisions would then need to be communicated to the functional elements throughout the organization.

At the level of functional program planning, current technology project alternatives need to be considered in terms of resources anticipated for the near-term planning period. Reflecting its close relation

to the organization's management control system, functional planning will usually have an underlying financial structure.[8] It is presented in direct association with monetary units in budgetary form and is constrained overall by the size of the estimated budget.

To arrive at recommended allocations of resources among candidate projects, technology program planning needs to include assessments of the alternative technical approaches available. The assessments would be based on such factors as a project's estimated contributions to the product lines or capabilities preferred for the future, the kinds of uncertainties likely to be encountered as a project progresses, and estimates of project costs for the coming and subsequent fiscal years.

The relationships incorporated in this idealized concept of long-range technology development planning are depicted in Fig. 2. In summary, the product/capability goals, resource assessments, and policy determinations which are the contributions of strategic planning provide guidance for the setting of technology subgoals and the assessment of technical alternatives. Other inputs to this functional planning process are the menu of available R&D projects and their estimated costs. The result of functional planning is a set of recommended resource allocations, chosen from selected technology project alternatives and constrained by current estimates of the next year's budget--in other words a recommended technology development program.

For such a concept to work in practice the respective products of the strategic and functional planning processes must be communicated freely among the responsible staff elements. Policy decisions made by top management concerning preferences for future product lines and capabilities need to be communicated throughout the organization. The technology subgoals and the results of functional staff evaluations of alternative technical approaches must be communicated to the strategic planners. But the respective products must be developed through processes and methods characteristically suited to either strategic or functional planning. Mutual information needs must not be met through

[8] Anthony, op. cit., p. 41.

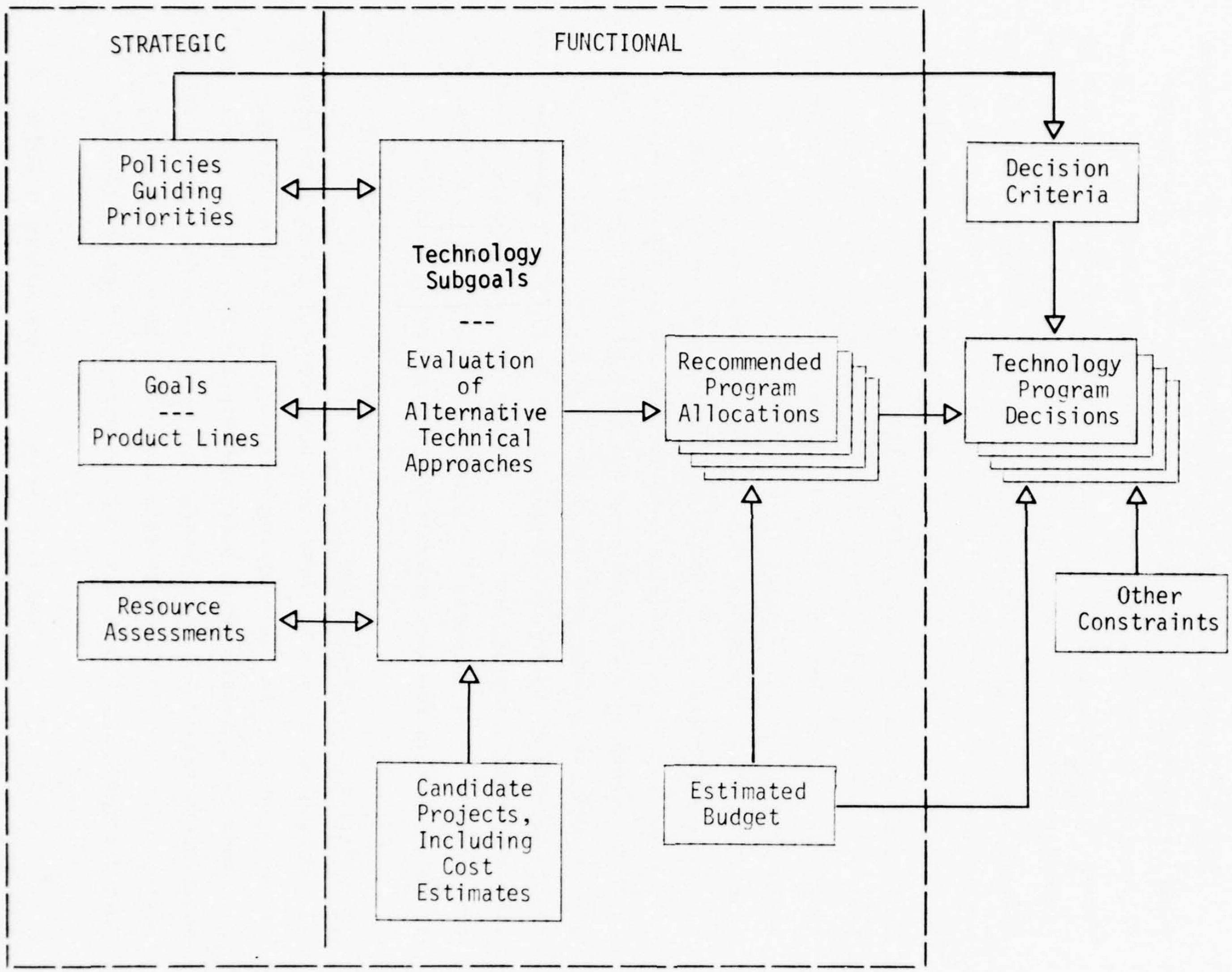


Fig. 2 -- Idealized long-range development planning process

artificial imposition of standardized procedures for generating information that fails to take into account the type of information.

Figure 2 also depicts the relationship of long-range development planning to technology development program decisions. The program allocations recommended as a result of the development planning process should be based heavily on long-range strategies for achieving future organizational goals. Particularly in complex organizations like the Federal Government, such recommendations are considered in conjunction with other shorter-term factors before firm program decisions are made. Decision criteria could include strategies calculated to win current budgetary approval from reviewing authorities known to have particular biases. Or they could include consideration of goals appropriate to the larger, parent organization. For example, a particular Defense R&D project might win support in order to affect the perceptions of other governments concerning U.S. intentions, even though its contribution to a specific U.S. capability might be regarded by U.S. military experts as less than significant. Similarly, particular projects could be constrained for reasons other than their technological promise. To continue the Defense analogy, a particular line of R&D might be denied because of an international treaty for which our government was trying to obtain foreign support. Finally, the annual budget must be considered anew as an overall constraint, particularly with respect to the competing resource demands of programs other than R&D.

## QUANTITATIVE R&D PLANNING MODELS

During recent years, there have been several attempts to develop and use quantitative R&D planning models. Some of these attempts were made in connection with Defense R&D programs. By and large, the models were relatively unsuccessful and were discarded after a trial period. In a survey of these Defense-related modeling attempts, reported separately,[9] their shortcomings were examined for possible

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[9] E. S. Ojdana, Jr., and J. P. Weyant, *An Assessment of Selected Models Used for Evaluating Military R&D Projects*, The Rand Corporation, R-1847-PR, September 1976.

implications that would aid in the search for improved development planning procedures.

Similarities and Differences

All of the models studied simulate only a portion of the overall long-range development planning concept described in the previous section. They are similar in that each oversimplifies the process to an assumed relationship between organizational goals (one aspect of strategic planning) and a menu of possible technology efforts (one factor in functional planning).

The models are quite different, however, in scope and specific output objectives. As shown in Table 1, the most important differences are in (1) the ways in which the menu of possible technological efforts is generated, and (2) the extent to which the method attempts to model the entire planning process. Some models start with proposed system concepts and identify all those R&D activities that will be needed to advance the technological state of the art to meet the requirements of the system. In other models, R&D activities were identified so as to define completely the domain of a technology or scientific discipline by its content.[10] While some models are only concerned with estimating the relative value of possible technology efforts, others attempt to model the entire process by selecting specific projects and allocating resources to them.

Table 1 also shows the four models that were analyzed as part of this study. TORQUE (Technology or Research Quantitative Utility Evaluation) was devised as a method for allocating Exploratory Development funds to DoD service laboratories and was tested within the Air Force in the late 1960s. RDE (Research and Development Effectiveness) was actually used to allocate resources at the Air Force Flight Dynamics Laboratory (AFFDL) for several years. Both TORQUE and RDE

[10] For example, aerospace flight vehicle technology might be broken down into structure technologies, aerodynamics, flight control, aeromechanics, and vehicle integration and operation. Each of these subcategories would then be defined by more specific content.

Table 1

SELECTED R&D PLANNING MODELS

| Model | R&D Activities Identified by | Model Applies Quantitative Method to | Other Models Using Similar Structures* |
|---|---|---|---|
| TORQUE | Conceptual system analysis | Entire planning process | Naval Ordnance Laboratory method |
| PATTERN | Conceptual system analysis | Part of planning process | Cornell Aeronautical Laboratory method, developed for Army<br>Army missile plan<br>Air Force Directorate of Laboratories method |
| RDE | Content of technological areas and scientific disciplines | Entire planning process | Hercules Corporation method |
| QUEST | Content of technological areas and scientific disciplines | Part of planning process | Army research plan |

*V. J. Bernati, W. S. Payne, and C. L. Trozzo, *Quantitative Methods for the Allocation of DoD Exploratory Development Resources*, Institute for Defense Analyses, Paper P-652, May 1972. See also C. L. Trozzo, *Description and Critique of Quantitative Methods for the Allocation of Exploratory Development Resources*, Institute for Defense Analyses, Paper P-731, May 1972.

allocated funds among development projects to maximize the military worth expected from a given R&D budget level.

PATTERN (Planning Assistance Through Evaluation of Relevance Numbers) was developed by the Military and Space Sciences Department of Honeywell, Inc., to aid in determining what current technological deficiencies were of importance to the national objectives for defense and science (and therefore likely to be funded). QUEST (Quantitative Utility Estimates for Science and Technology) was proposed as a method to determine the relative value for military mission use of various scientific disciplines and technology areas. Both PATTERN and QUEST essentially provide rank-ordered lists of projects as an output. Although PATTERN has been applied to operational Air Force problems, neither has actually been implemented by the services.

These models all use the benefit contribution approach in assessing the relative value of an R&D project, i.e., a project derives value according to its contribution to achieving some explicit R&D objective or system requirement. For example, in TORQUE and PATTERN, system concepts are postulated which will meet a set of operational capability objectives. The concepts are assigned numerical values reflecting their relative importance for achieving these goals. An R&D project is assigned a portion of the value of a particular concept, the amount assigned being dependent on the contribution the R&D project makes to meeting the system requirements. The total value of the R&D project is estimated by adding up all the values it receives by virtue of its contributions to achieving the requirements of each conceptual system.

## Summary of Problems

It is useful to summarize briefly the major limitations of these models. The limitations can be categorized into two broad groups: structural problems and operational problems.

Structural Problems. Military R&D planning models should, at the minimum, be structured to assure that future decisionmakers will have available to them a wide range of options for dealing with the situations they may confront. This may involve deploying a completely new system (e.g., B-1), or upgrading forces in being by product

modifications (e.g., new engines). Three of these models (TORQUE, RDE, and PATTERN) have not been structured to encompass such options.

In particular, the generation and preservation of options is restricted by the use of system concepts in the model structures. This occurs through (1) limiting the flow of innovative approaches for solving operational problems and (2) treating the system concepts as extensions of the current force structure rather than a set of options for developing future force structures.

The system concepts frequently state the desired operational capabilities in terms of the currently used technical approach. In TORQUE, for example, one of the conceptual systems was a tactical aircraft with specified approximate performance characteristics (gross weight, speed, endurance, and armament payload in terms of guns, bombs, rocket pods and bomblet units) and with a number of associated systems necessary to carrying out the close-air-support-mission tasks (i.e., detecting targets, coping with defenses, etc.) also specified. Assuming that all these functions will be incorporated in a single manned aircraft ignores the possibility of accomplishing these tasks by alternative means. For example, other innovative ways have become available since the TORQUE test (1968) that could have accomplished some of the close-air-support-mission tasks without the use of manned aircraft (e.g., remotely piloted vehicles) or manned aircraft that contain the entire system to perform the tasks (e.g., laser target illumination from the ground).

Options are precluded when the system concepts are treated as extensions of the current force structure. In the models, a future force structure is developed to meet those future operational needs, ranked in importance according to some scenario (PATTERN) or expected world situation during some time period (RDE and TORQUE). In TORQUE and RDE, the system concepts are time phased into the current force structure to be available at the time the new systems will be needed. The system concepts make implicit assumptions about the future world and cast them into very specific system parameters; supporting R&D projects will be evaluated and selected according to their contribution to these systems. But these projects may be inappropriate for

the situation which actually occurs and future decisionmakers may be left with no options with which to develop alternative force structures. Treating the system concepts as extensions of the current force structure thus assumes that the future world can be projected with a high degree of certainty.[11]

Operational Problems. The operational problems of the models are rooted in (1) the assumptions about worth-independence contained in their assessment schemes and (2) the highly subjective nature of required model inputs.

All of the models require that goals or objectives be assigned a relative importance value. The objectives typically used in the military R&D planning models (e.g., interdiction, providing close air support, etc.) are not worth-independent because they exhibit synergistic effects when combined. Worth-independence implies, for example, that the value of having both the capabilities to interdict enemy forces and to provide close air support to friendly forces is equal to the sum of (1) the value of having only the interdiction capability (without close air support) and (2) the value of close air support (without being able to interdict enemy forces). If there is any synergism (having both jointly is better than the sum of the two taken separately) or if having both jointly is worse than the sum of the two, the goals or objectives cannot be treated as worth-independent. Worth-independence also means that decisionmakers are indifferent to alternatives (e.g., system concepts or R&D projects) with the same overall worth scores. That is, the decisionmaker does not care if worth was maximized by satisfying only one goal to the exclusion of all other goals. The worth-assessment schemes of the models will not yield valid and reliable estimates of the relative values of R&D

[11] One way to test the appropriateness of the force structures generated for the models for other possible world situations (assuming that missions or operational tasks can be defined which are relatively invariant over time) is to determine the sensitivity of the worth of the systems to variations in the relative importance of the operational capability objectives for which they were designed.

projects if the worth-independence assumption is violated, as it appears to be in the models examined.

Other operational problems arise from the fact that the inputs required to exercise the models are generated by technical experts and are highly subjective in nature. The way the model methodologies treat expert opinion is, therefore, a major determinant of the validity and reliability of the model outputs. Problems concerning the model inputs arise from the procedures used to: (1) select expert participants, (2) make forecasts of model inputs, (3) measure, collect, and aggregate judgments, and (4) define the scenario(s) for which the model inputs are generated.

In selecting participants to provide the model inputs, the model methodologies have relied on people who normally generate such information within the organization. Experts on policy and doctrine prepare and rank operational requirements, system planners develop system concepts, and engineers evaluate needed technology and the contribution of R&D activities to satisfying the system requirements. But worth-assessment schemes (such as the models) are geared to help individual decisionmakers and are employed most easily when an individual can handle the entire process. In complex organizations where the assessment scheme requires many and varied inputs, technical experts perform all the assessment activities, including suggesting preferences for operational objectives to senior executives. Unless the objectives are endorsed by responsible executives--and this has not always been the case--the outputs of the models are not likely to be seriously considered by lower-level R&D managers. Additionally, the model methodologies do not recognize that technical experts can differ; procedures to select experts to supply the model inputs or to judge the quality of the inputs are not provided.

Little guidance is provided in the model methodologies on how estimates or forecasts or model inputs should be made; the models rely on the participants' discretion--a further indication of the need for assessing the quality of expertise. Thus, even though great care may have been taken in preparing the inputs, the impression given is

that model inputs are obtained in a trivial manner and rely primarily on intuitive judgment. The models themselves are a form of normative forecasting but this forecast is only as good as the model inputs.

No guidance is provided on how judgments are to be measured, collected, and, in some cases, aggregated. Differences in judgments among participants regarding the model inputs (e.g., importance of a goal, contributions of an R&D project) reflect the uncertainty surrounding the inputs. This uncertainty is not reflected when such judgments are averaged or voted upon. Also, judgments are affected by individual perceptions of the object which is being judged and of the situation for which it is being judged, yet little care seems to have been taken to assure that perceptual differences among participants are minimized.

Assumptions regarding the future world situation have been treated in two ways by the models: (1) participants providing rankings of the goals use their own expertise regarding the most probable state-of-the-world situation; or (2) a specific scenario is provided. Neither of these procedures captures the uncertainty of such forecasts. As pointed out earlier, system concepts and supporting R&D designed for specific future situations may not provide future decisionmakers with alternatives to cope with the actual future situations.

## Conclusions

In light of these methodological problems it is not surprising that large computer-based R&D planning models have been relatively unsuccessful. Nor is the future of such models particularly promising. The models cannot capture all the relevant and subtle influences that affect the R&D planning process. The models have consequently been advocated as decision information systems to aid managers in R&D planning. However, the methodological problems are of such consequence that the model outputs are not valid even for this purpose.

## INDUSTRIAL R&D PLANNING PRACTICES

While there are obvious differences between the Air Force and industrial firms, the R&D planning practices of large, organizationally

complex firms that are deeply involved in advanced technologies offer some interesting insights. Table 2 lists the corporations that were examined as part of our survey of industrial planning practices and provides a basis for comparing the Air Force and these firms in terms of sales, R&D expenditures, and product-line diversity. Some of the larger firms are of the same order of magnitude as the Air Force; for example, in calendar 1974, GE and IBM sales each amounted to around $13 billion, while the total Air Force budget for fiscal 1975 was about $25 billion. The sales of AT&T, whose R&D work is done by Bell Laboratories, were even larger than the comparable Air Force budget. On the other hand, the Air Force, as shown in Table 2, maintains a much larger R&D budget and greater R&D effort relative to its total program than do any of the corporations listed.

Among the firms surveyed, a wide spectrum of R&D planning practices was observed. One firm (AT&T) had neither a planning staff nor a formal planning process in the belief that the research managers are the individuals best qualified to decide what projects should be funded. The other firms had a structured process that relied on subjective judgments to decide which projects should be pursued. Two firms (GE and Rockwell International) used quantitative scoring methods, but only to aid managers in the selection process. In all of the firms surveyed, the final R&D program decisions are the responsibility of senior corporate managers.

The similarities that were observed among the firms may serve to highlight some of the practices followed by the Air Force (to be described in the next chapter). These similarities are of two types: organizational and procedural.

The major organizational similarities observed were:

- The senior R&D executive is always a qualified scientist.
- The review and decision chain is short.
- R&D is separated from other corporate planning, programming, and budgeting activities.
- Separate staffs carry out corporate strategic planning and R&D program planning.

Table 2

CORPORATE AND AIR FORCE R&D

| Company and Type of Product | Size of Operation or Sales[a] (CY 74) | Company-funded R&D[a] (CY 74) | Govt-funded R&D[b] (FY 74) | Total R&D | Ratio of R&D to Sales or Size of Operation (%) |
|---|---|---|---|---|---|
| | in millions of dollars | | | | |
| General Electric<br>Diversified | 13,412 | 351.8 | 365.9 | 717.7 | 5.4 |
| AT&T<br>Diversified | 26,708 | 584.3 | 0 | 584.3 | 2.2 |
| IBM<br>Computers, electronics, office equipment | 12,675 | 889.9 | 24.6 | 914.5 | 7.2 |
| Xerox<br>Copiers, computers, data facsimile | 3,578 | 178.8 | 1.4 | 180.2 | 5.0 |
| Rockwell<br>Diversified | 4,413 | 40.5 | 211.6 | 252.1 | 5.7 |
| TRW<br>Aerospace, tools, automotive parts | 2,486 | 29.6 | 44.0 | 73.6 | 3.0 |
| Northrop<br>Aerospace, electronics | 853 | 20.4 | 8.9 | 29.3 | 3.4 |
| Air Force (FY 75) | 25,042[c] | | | 3,299[d] | 13.2 |

[a]Includes (1) expenses associated with the search for and discovery of new knowledge that may be useful in developing new products, services, processes, or techniques, or that might improve existing products or processes, (2) all development costs of significant new products and processes, and (3) costs of design, construction, and testing of prototypes as well as operating costs of pilot production facilities, in accordance with Accounting Standard #2 for R&D. These expenditures were reported to the Securities and Exchange Commission on Form 10K. Source: Based on data in *Business Week*, June 28, 1976, pp. 64-84, *passim*.

[b]Contracts awarded during CY 1974. Source: *Research and Development Directory*, 1975.

[c]Source: *The Air Force Budget*, February 1976.

[d]Program 6: Research and Development. Source: *The Air Force Budget*, February 1976.

The senior R&D executive serves as a bridge between the executive leadership of the corporation, which has responsibility for the firm's overall program, and the functional R&D elements of the corporation. In all companies, he is a member of the corporate executive committee that decides not only on R&D budget allocations but on allocations to all other parts of the firm. As a qualified scientist he is in a position, along with the company's Chief Scientist, to advise other members of the executive committee on technical matters as well as to direct the various technology development activities of the company. In one of the firms we observed (Xerox), the R&D executives are given a wide latitude in deciding what R&D projects are to be pursued, as corporate management feels that these officials are best qualified and uniquely positioned to judge the potential value of a particular R&D project.

The lines of communication and authority between the technology development activity and the top management are extremely short. The laboratory directors typically report to a Vice-President of Research and Development who, in turn, reports to the chief operating executive or to an executive committee, of which he is a member. Program and budget reviews are also conducted directly with the top management of the firm. At Xerox, for example, the Vice-President of R&D and each individual laboratory manager jointly present their plans and budgets to an executive committee.

Finally, the R&D budgeting and planning procedures, as well as the research organization itself, are separate from other corporate budgeting and planning activities. This is an implicit recognition that the management and functional planning methods appropriate for operating divisions are not appropriate for R&D.

The following similarities were observed in the actual planning procedures and practices of the firms:

- Long-term product-line goals are frequently assessed in an orderly manner.
- Planning staffs are small and serve directly their respective top managers.

- R&D planning is structured, but quantitative methods are not widely used.
- The planning process is viewed as a useful communication device.

All the R&D planning processes that we observed reflected the hierarchy of corporate goals of its respective company. And all of the firms surveyed had a clear understanding of the direction in which they were headed. This was the result of rather frequent assessments of long-term (strategic) goals by corporate management, assisted by a corporate planning staff. The senior R&D executive thus participates in establishing corporate goals as well as seeing to their pursuit in the R&D program. The assessments are normally performed in a highly systematic manner as part of the company's strategic planning process.

One of the interesting aspects of industry's R&D program planning practices is the role of the special R&D planning group. In all the companies except Bell Laboratories, this staff was an entity separate from the corporate planning staff. Its work was directed and structured by the senior R&D executive, and it served him directly. The R&D planning staffs influence R&D planning but are not responsible for selecting R&D projects; doing this is the province of senior operating executives. Rather, the role of the planning staff is that of articulating the functional planning process with the company's strategic planning. Members of the planning staff exert considerable influence on R&D goal setting, since they often get the first cut at rank ordering the potential R&D projects from lists provided by individual laboratories. A consolidated list of recommendations is then prepared and sent on to the senior R&D executive, who presents it to the corporate committee for consideration. In this way, the planning staff can flag a project that should be brought to the attention of the senior operating executives when it might otherwise not have been examined. Thus, they assure that potentially important projects are not overlooked and also that projects are not overranked because a laboratory director wants to assure that a particular project is funded.

As noted previously, the actual planning process is very structured. Although not highly quantitative, scoring algorithms and certain other quantitative techniques are used to aid in the process. The process starts by identifying the organization's product-line goals, matches the goals with R&D projects, which are then ranked in order of importance to the firm, and ends in the selection of R&D projects based on the subjective judgment of senior executives.

Firms see the communication value of the planning process as one of its most important benefits. The goals of the organization are clearly communicated to R&D managers. The process is highly visible and the criteria used in selecting the projects are normally understood by laboratory managers and senior executives alike.

## An Example

To illustrate the characteristics of industrial R&D planning, an example of the R&D planning process used at General Electric corporate R&D laboratories is presented (see Fig. 3).

The GE process starts with the identification of long-term goals. At the level of corporate management, objectives are derived from a series of scenarios prepared by the corporate planning staff in which alternative technology futures based on the interplay between such factors as technological advances, competitive factors, and broad corporate policy are outlined. These scenarios are updated roughly twice a year, and appropriate adjustments and refinements are made to the corporate objectives. Additionally, the chief executive of each of the several product divisions annually submits a list of his needs, based on his division's perceptions of how its market performance can best be enhanced. At the same time GE also considers new technological ideas, opportunities, and risks as well as the current corporate research and development (CRD) programs to which resources are committed.

This process yields a list of candidate CRD programs that appear generally responsive to corporate policy and needs. As a first step in the evaluation of these programs, the R&D planning group divides the candidate list roughly into two parts: (1) projects with substantial uncertainties that prevent definition of a development

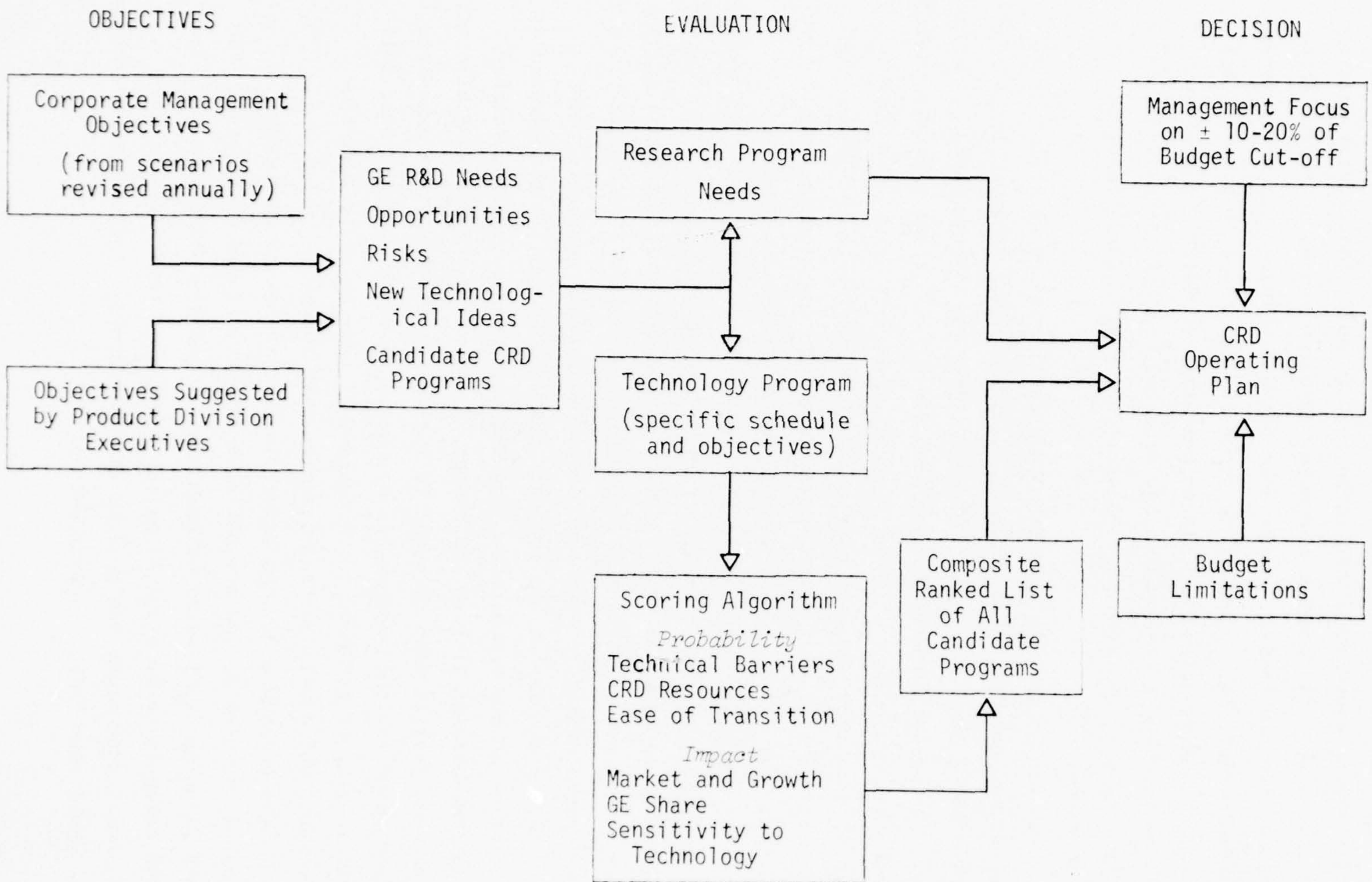


Fig. 3 -- R&D planning at GE

program (i.e., research or "knowledge-generation" projects), and (2) projects where the basic technology is sufficiently well developed so that a specific product technology program can be defined. This second category closely corresponds to what we have called "advanced hardware DT&E" in the Air Force program. The research projects are highly speculative and undertaken primarily on faith. The great bulk of R&D funds go to the technology program, and GE's procedures for selecting projects from this category are particularly relevant to this study.

GE uses a scoring algorithm to judge the value of each potential technology program. Each project is ranked using a short list of criteria and a numerical scale for each criterion so that overall numerical ranking can be determined for each project. These criteria consider both the probability of carrying out the project (e.g., are there significant technological barriers to overcome?) and the impact that the project will have on GE (e.g., is the potential market sufficiently large? what share of that market can be obtained by GE?).

Although not a precise method, the ranking does permit the projects to be grouped into at least three categories: those that clearly rank high in potential value, those that are clearly low in value, and those that are in between. Those that rank high will almost certainly be pursued and those that rank low will probably never be funded.

It is the in-between projects that are brought to the particular attention of top management. The R&D planning group first matches the rank-ordered list to the budget, i.e., they estimate fund allocations for each project down through the list until the budget is exhausted. Management can then devote its attention to those projects that fall within plus or minus 10 to 20 percent of this budget cutoff line, deciding which will be funded and at what levels.

The procedure is kept quite flexible to insure that projects ranking either high or low are not automatically funded or deleted. The R&D planning staff examines each project and can place a project in the category to be examined by top management regardless of the original rank order assigned by the laboratory. Individual laboratory managers also have this prerogative.

Planning Implications

The GE example clearly illustrates many of the R&D planning practices of industrial firms. Although GE uses a quantitative method for arriving at an initial ranking of projects, the method is not a substitute for executive judgment. It does help the corporate managers to focus on those areas where their particular judgment and expertise is needed.

One other example of the use of a scoring algorithm was found at Rockwell International. This firm defines a number of dimensions for rating each program. They very specifically define the criteria used to assign a value to a project on each dimension. The result provides management with a concise display of the overall outlook for the project. As with GE, this scoring algorithm is used as an aid to management.

Our survey of industrial practices revealed some implications for any future development planning methods that might be adopted by the Air Force. The fact that the use of large, sophisticated, quantitative R&D resource allocation models is not practical at this time does not mean that quantitative techniques, such as scoring algorithms, should not be used to aid the planning process. Such methods have proved useful in industrial firms. But to be useful, these techniques must start with a clear statement of organizational objectives. These objectives must be explicit and assessed frequently. Using analytical techniques as an aid, the entire planning process can be organized and systematic.

# III. CURRENT PLANNING WITHIN THE AIR FORCE RDT&E STRUCTURE

Planning activities which affect Air Force Research, Development, Test, and Evaluation, RDT&E,[1] are distributed among various levels of the R&D community and among areas of the Air Staff other than the R&D community. The responsibility of Hq USAF in the field of RDT&E is to "provide policy guidance, describe objectives, establish priorities, and control and balance the distribution of resources. . . ." The Air Force Systems Command Headquarters and the field organizations under it are tasked to "plan, formulate, and execute research and exploratory developments consistent with Hq USAF policy guidance and resource allocation." They are also to "formulate and submit" an annual R&D program and to conduct studies and analyses which continuously define and redefine R&D objectives, provide necessary data for Air Staff decisionmaking, and improve long-range resource planning.[2]

In this chapter, the specific RDT&E planning actions of these organizations will be described, together with several planning and programming activities related to these actions. For analytical purposes and for ease of exposition we shall examine the relevant activities of the Air Staff and AFSC in terms of our development planning construct. And we shall, insofar as possible, discuss and relate these activities in the context of the program of a single fiscal year, as if they could be isolated from other staff actions and observed seriatim.

In actuality, the planning process affecting Air Force 6.2 and 6.3 technology development programs is characterized by continuous staff interactions of both a structured and unstructured variety. The

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[1] RDT&E is Program 6 of the ten programs comprising the Department of Defense Planning, Programming, and Budgeting System (PPBS), into which all Service and Defense agency activities are aggregated for management purposes. Different categories of RDT&E, e.g., Research, Exploratory Development, Advanced Development, etc., are designated 6.1, 6.2, 6.3, etc.

[2] Air Force Regulation (AFR) 80-1, 24 June 1970, p. 3.

planning operations are iterative and involve almost daily coordination of staff evaluations and resource estimates between Headquarters AFSC and the Air Staff. Most program reviews by staff committees deal with more than one fiscal year's program at a time and recur frequently throughout any calendar year. The process is highly dynamic and is influenced in major ways by the personal interactions of individual members of different participating agencies.

One problem affecting these interactions--particularly the more formal staff interactions--is that different portions of the Air Force R&D community and of the Air Staff have had different perceptions of development planning. For example, the planners and programmers who are responsible for preparing the future-force projections for the annual Defense PPBS documents have considered their staff organizations as the true planners of the future Air Force; their traditional view is that the R&D community should be limited to developing those systems which they have determined were needed. While acknowledging the need for force-planning guidance, the R&D community, on the other hand, has regarded planning for the development of future systems as a proper function for itself.

Yet, even within the Air Force R&D community, perceptions differ as to what should constitute long-range development planning. Air Staff members of this community have traditionally regarded such planning as properly their responsibility, with AFSC limited to an implementing role. Moreover, some within the R&D community, in both the Air Staff and AFSC, regard development planning as strictly the assessment of what kinds of weapon systems should and can be developed, based on considerations of perceived future capability needs and projected states of available technology. Others feel that development planning should give maximum encouragement to technology evolving in the laboratories and should emphasize how that technology can best be exploited by the Air Force in the future.

In this chapter and for much of the remainder of the report we shall avoid the term "development planning," so as not to appear to be taking sides in these controversies. Rather, we shall speak only

of the kinds of planning considerations which we believe essential in terms of the construct described in Chapter II.

AIR STAFF PLANNING

A significant feature of Air Staff RDT&E planning is that it corresponds to the second of the two types of planning described above in Chapter II. It is more a management control function than strategic planning. This situation exists largely because of its close links with the annual PPBS cycle. Air Staff planning actions for RDT&E contribute directly to elements of this cycle.[3]

The PPBS cycle for any single fiscal year's Defense RDT&E program consists of a series of staff actions extending over an 18-month to 2-year period (Fig. 4). These actions culminate in three iterations of the DoD budget for Program 6 and require planning inputs from the Air Force and each of the other services. The first of the inputs is the annual Program Objectives Memorandum (POM) exercise to formulate the Air Force program, line-item by line-item. Each line-item or program element is projected forward for a five-year period, in effect adjusting the Five-Year Defense Plan (FYDP) for Air Force RDT&E. The POM serves as a base-line plan until decisions are made for the second iteration, the Budget. In its turn the Budget, submitted to DoD each October, is the planning base until Apportionment decisions, the third iteration, are made. The Air Staff, assisted by Headquarters AFSC, carries out all three of these actions (on different fiscal year programs) each year. Particularly in the spring, Air Force participants in the planning often work concurrently on RDT&E programs for three different fiscal years--shifting funds for the current spending year as required by Congressional appropriation decisions, making adjustments in next year's proposed budget based on departmental allocation decisions made at White House level, and preparing inputs for the POM pertaining to the program to begin two years hence.

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[3]See Appendix A for a detailed description of the Air Force RDT&E Planning, Programming, and Budget cycle.

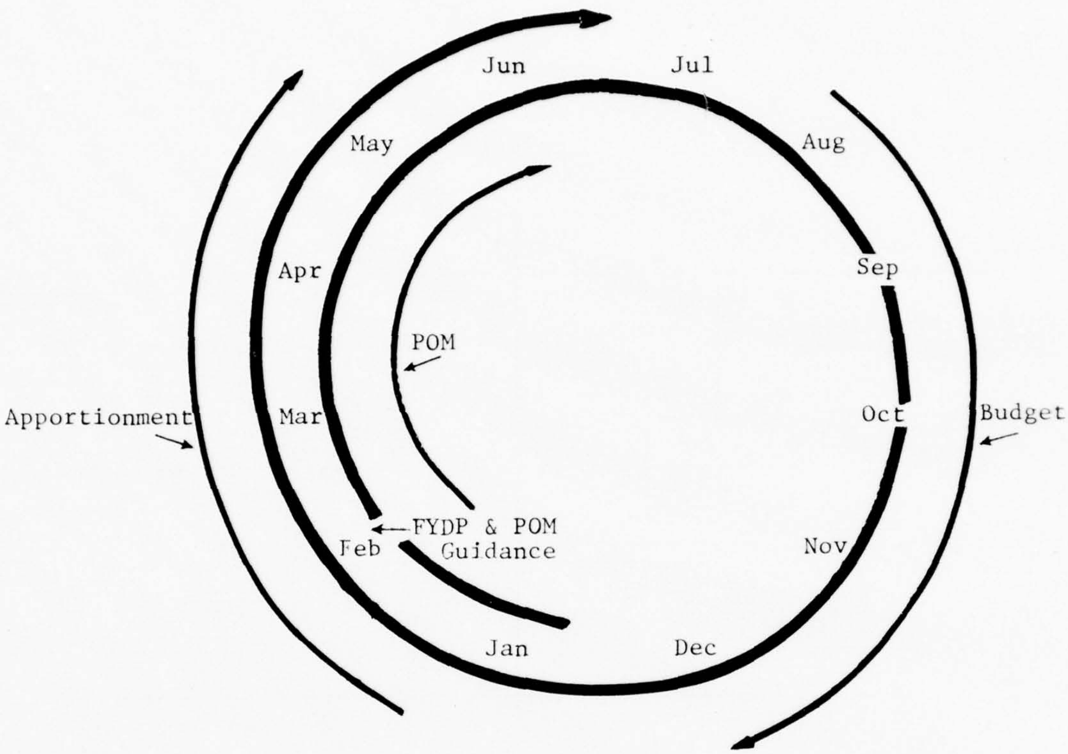


Fig. 4--Elements of Defense PPBS planning cycle, e.g., Fiscal Year 1976

For all three Air Force inputs to formulation of a single fiscal year's RDT&E program, Air Staff actions describe a similar pattern. All RDT&E program elements in the current base-line planning document (FYDP for the POM exercise, POM for the Budget exercise, etc.) are reviewed individually by a hierarchy of staff groups under authority of the Deputy Chief of Staff for Research and Development (AF/RD), the organization of which is shown in Fig. 5.

Initial review of the composition and resource allocation for RDT&E program elements is conducted by a working group of staff officers from several AF/RD directorates (pre-PRG), headed by a colonel, which recommends funding levels for each program element to the Program

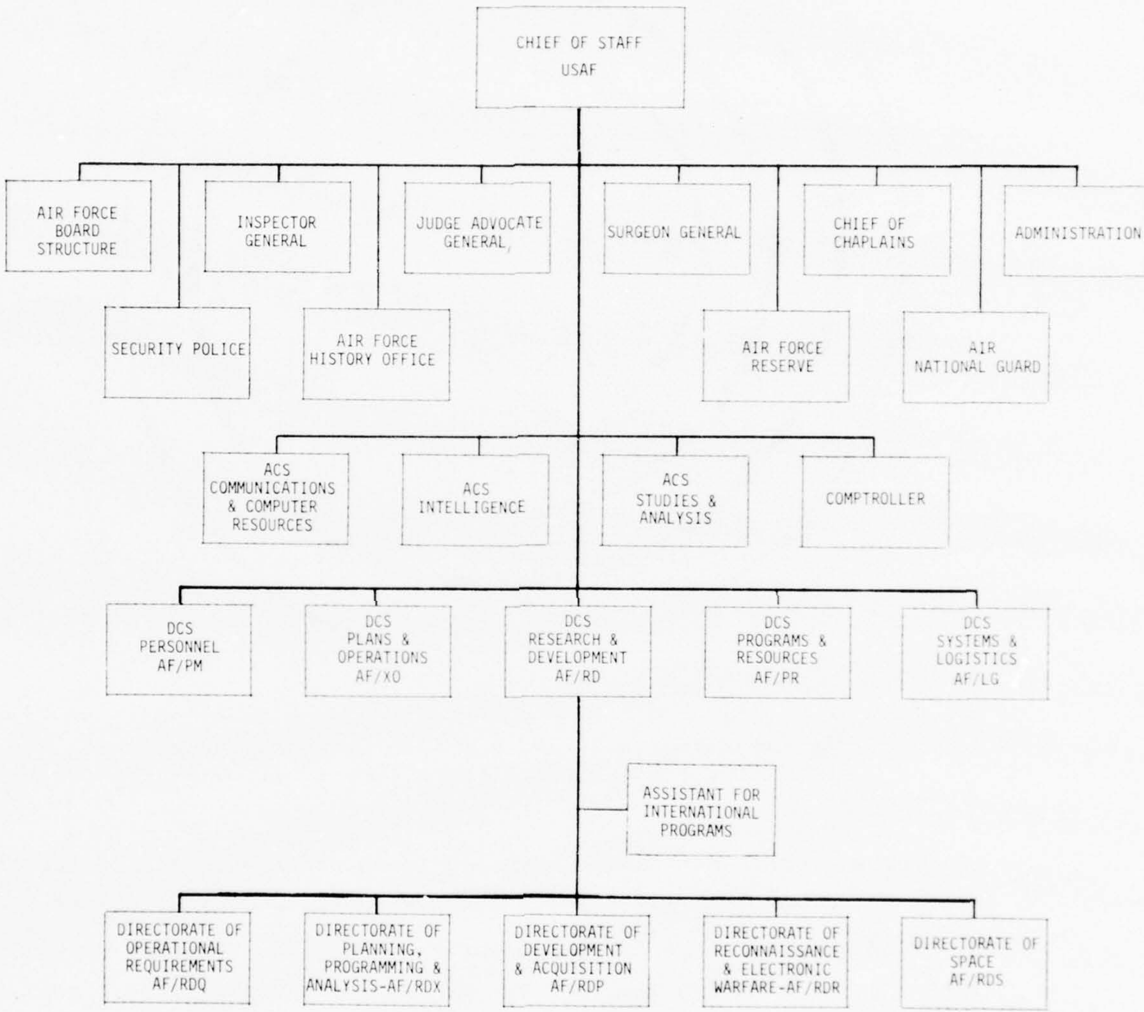


Fig. 5--Organization of the Air Staff and DCS/Research and Development

Review Group (PRG). This group is composed of the general officers heading each of the AF/RD directorates. Parallel reviews are conducted by counterpart groups in Headquarters AFSC, and informal attempts are made to resolve differences between the two organizations before their respective positions are forwarded to the next review level. Finally, a joint AF/RD-AFSC general-officer review may be conducted at the discretion of AF/RD to arrive at a single recommended program to be submitted to the Chief of Staff and Secretary for approval.

These Air Staff actions represent distinct functions in terms of launching other planning and implementing actions in the field. In the case of 6.2 programs, for example, the Air Staff makes decisions, based on recommendations by AFSC during Budget formulation, on the rough allocation of funds among the different areas of technology represented by the 11 program elements. After Budget time, the Air Staff in effect hands over the programming authority or the allocation of funds within the program elements to AFSC Headquarters and the laboratories. For the 6.3 category, the Air Staff makes decisions on program elements, in some cases down to project and task-level detail, through the period of the Apportionment action. After Apportionment, the Air Staff issues Program Management Directives (PMDs) that direct AFSC, its product divisions, and laboratories to carry out the development according to specified tasks and funding. These organizations must adjust their planned allocations and work units within the guidelines prescribed by the Air Staff.

## PPBS Cycle Interaction

The PPBS cycle for a given fiscal year constrains RDT&E program planning in the following ways:

First, there is no clear-cut beginning of the cycle for the R&D community. The Office of the Secretary of Defense (OSD) hands down with the FYDP a bogey dollar figure for the budget, guidance by program category, and, in effect, commitments to a slate of ongoing RDT&E program elements. As each cycle begins, the R&D programmers face, for the most part, not a fresh new menu of technology efforts

but a continuation of programs and projects already under way. And, in truth, few worthwhile technology development projects can be completed within a single year.

This conditional beginning of the cycle tends to constrain the planners in allocating a major part of their funds. Although actual funding commitments to industry cannot extend beyond one budget year, contracts to industry for 6.2 and 6.3 programs are awarded on the basis--among other thing--of multiyear projections of their development schedule. Thus, the current projects in progress, schedules and milestones previously approved, and commitments to an emerging technology all tend to weigh heavily in determining how available resources will be utilized.

Second, the constraint of a limited budget dominates all Air Staff planning decisions. At each level of review and decision the focus is on funding--whether the budget can be cut or slipped, whether justification for the expenditure is hard or soft. For example, one task assigned to the pre-PRG each year is to develop a cut list of "soft" programs or projects for possible excision by the AF/RD's Program Review Group.

Third, the PPBS cycle imposes a program-element-by-program-element format and a hierarchy of reviewing authorities; this encourages an incremental approach to RDT&E program formulation. Reviewers, operating under deadlines for the next staff level of review, examine each item as a separate entity, comparing it with the current base line and the FYDP. The review schedule is crowded, under tight deadlines, and limits the opportunities of the formal reviewing group to see how the programs compare with alternate programs in their relative contributions to future objectives. If this has been done in prior informal staff efforts, the reviewing groups may get to consider only the resulting recommendations.[4]

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[4]Beginning with preparation of the POM, FY 1978-1982, accomplished during the early months of 1976, Air Staff RDT&E program planners were briefed on program alternatives for different Air Force mission areas by representatives of the DCS/Development Plans, Headquarters AFSC.

Participants in Air Staff

Planning actions affecting the 6.2 and 6.3 program in the office of the Air Staff are accomplished by staffs of the AF/RD with guidance from the Assistant Secretary for Research and Development (SAFRD). In addition, there are occasional inputs to the planning process from other directorates in the Air Staff; these will be discussed below. Unlike other Air Force programs over which the Air Force Board Structure exercises strong influence, the RDT&E program in the POM has been formulated since 1971 solely in AF/RD.[5] R&D community control over the program is continued without substantial Board influence through the Budget and Apportionment iterations.

Air Staff RDT&E program recommendations result from continuous interactions among many elements of the Air Force R&D community. Program element monitors (PEMs) for the 6.3 programs in the Directorate of Development and Acquisition and the Directorate of Operational Requirements[6] are in frequent contact by telephone with counterparts at AFSC, and they make periodic staff visits to field organizations responsible for carrying out the development work. At each stage of the program-planning cycle, parallel program reviews are conducted by working groups in both the Air Staff and Headquarters AFSC. The groups communicate freely to assure that their respective judgments are based on common information. Their respective general-officer review groups--AF/RD directors in the Air Staff and DCS-level officers in AFSC--also sometimes work together in joint session to iron out differences on a program before recommending it to the Chief of Staff.

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[5]For RDT&E, the role of the Air Staff Board's Program Review Committee (PRC) in POM formulation has been limited, in effect, to reviewing the AF/RD submission and recommending aggregate changes in the funding estimates. Any decisions on changes at the program element level are made by the AF/RD.

[6]The PEM is expected to (1) assist with developing justification for program changes in his element(s), (2) prepare revised program element definitions, (3) maintain necessary data on major aspects of his element(s) and prepare progress reports to OSD, (4) review program and cost data in FYDP and advise appropriate Office of Primary Responsibility (OPR) and budget office of any changes believed necessary. (Paraphrased from Hq USAF Office Instruction (HOI) 27-1.)

Throughout the year, program formulation is influenced also by occasional interaction between Air Staff PEMs and staff members from the office of the Director of Defense Research and Engineering (DDR&E). The formal channel for communication between the Air Staff and DDR&E is through SAFRD. The intensity of this interaction increases markedly at the time of Budget formulation. Typically, however, there is informal contact between the AF/RD and DDR&E staffs during the POM and Budget markups regarding the funding of certain programs and projects. Air Force programming of all interservice development projects for which it is responsible must be cleared formally through DDR&E. DDR&E holds triservice budget reviews by selected technology area in October and November after the service budgets are submitted to OSD. A limited number of reviews are also held during the Apportionment cycle wherein DDR&E and Air Force representatives review selected Air Force RDT&E programs by technology area, or, if necessary, by program element and project.

Inputs into Planning Actions

RDT&E planning actions are based on a variety of inputs and influences from a number of Air Force sources.

Aside from its role in determining fund allocations among various 6.2 and 6.3 program elements, the Air Staff R&D community also formulates and issues "requirements" documents intended to serve as guides to planning and program formulation. This is accomplished through the "ROC process." Usually originating as a user's statement of need or deficiency in the operational command, the Required Operational Capability (ROC) comes to AF/RD after review by AFSC and AFLC (Air Force Logistics Command). It is circulated to all Air Force major commands and undergoes a formalized validation process in Hq USAF before it is considered a prospective requirement for a new system or capability.

Validation is carried out by a corporate Air Staff body, the Requirements Review Group,[7] to determine whether the ROC is consistent

[7] Members of the Requirements Review Group are: the Director of Operational Requirements (AF/RDQ) (Chairman), the Director of Development and Acquisition (AF/RDP), the Director of Reconnaissance and

with the Air Force objectives and mission and to recommend approval or disapproval of further action. After validation, the Air Staff action officer informs counterparts in other services of the ROC in order to get joint harmonization of military requirements. A validated ROC is widely circulated throughout the Air Staff and AFSC and serves to disseminate guidance for the proposed new system or equipment to technology and force planners at all levels. However, prior to its implementation in a development program, it must successfully compete for funds.

A further influence on RDT&E planning in the Air Staff is the practice of program advocacy. Every "program officer," action officer, or PEM in AF/RD is charged with being an advocate for his particular technology effort. Once a technology effort has been reflected in an approved annual RDT&E program, the PEM appointed to shepherd that effort through Air Staff administrative actions is expected to influence favorably any program decisions that will assure the effort's being continued until its objectives are achieved. Particularly in the case of a 6.3 program element, the PEM's advocacy can be a significant factor in determining the kind of support it receives in the periodic RDT&E program reviews. The advocacy function of the program officer in the Directorate of Operational Requirements extends also to candidates for a future program--for example, a technology for which there is a validated ROC or a system proposed by a contractor--in an effort to gain funding for it in some future RDT&E budget.

Because of the competition for funds, the advocate, as the term implies, must strive to influence reviewers and program planners within the Air Staff, AFSC, and DDR&E who participate in shaping the budget. Since support by general officers is viewed favorably by those responsible for formulating the R&D program, the advocate actively seeks such high-level sponsorship for his program, both in the R&D community and from other areas of the Air Force.

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Electronic Warfare (AF/RDR), the Director of Programs (AF/PRP), the Director of Operations (AF/XOO), the Director of Plans (AF/XOX), and the Director of Maintenance. Engineering and Supply (AF/LGY). AF/RDQ has Air Staff responsibility for review, validation, and advocacy of the ROC until it is funded.

Implicit in the Air Force incentive system as it affects the advocate is his association with a program which has obtained funding and progressed through development. A technology program which the Air Staff advocate guides through the pitfalls of R&D toward system integration is a step up the career ladder. If the advocate is successful in obtaining support for a shift in emphasis within his program, and, in effect, achieving a new consensus with respect to the subgoals for that program element, his immediate supervisors are awarded side payments in the form of funding support for the program and he achieves recognition as being instrumental in bringing about a program change. There is little payoff apparent for having advocated an alternative approach to a recognized capability objective which loses out, for whatever reason, in the competition for available funding.[8]

Beyond the identification of requirements expressed in the ROCs, the official view of what is desired in a future Air Force are varied and uneven. The only operative Air Force statements of future capability objectives presently being produced are the force programs in the POM and the Extended Planning Annex (EPA) to the POM.[9] The force projections in the POM go eight years into the future, the last three of which are not costed. The EPA projects six to fifteen years, and all projections are costed within the degree of uncertainty inherent in such distant estimates. The EPA briefly describes major new weapon and support systems and estimates funding profiles for their development, procurement, and operation within prescribed and stable overall resource assumptions. The new systems are identified in terms of replacements for existing systems. Thus, the EPA reflects the need for some continuity in force structure and the expectation that

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[8]This fact of life in Air Force RDT&E management applies not only within the Air Staff but throughout the R&D community.

[9]Force programs in the EPA include strategic forces (bomber squadrons/UE and missile UE), tactical air squadrons/UE, airlift squadrons/UE, and control and surveillance systems (aircraft, radio, command centers, and space systems) UE.

systems once procured will be relied on for an extended service life. However, the document also assumes continuity with respect to current missions and with respect to reliance on follow-on states of the current art, i.e., aircraft to replace aircraft, missiles to replace missiles, satellites to replace satellites, etc.

Production of the POM and EPA is supervised by DCS/Programs and Resources (AF/PR), while the inputs are the responsibility of various directorates throughout the Air Staff. All replacement force planning for the documents is furnished by the Director of Plans (AF/XOX), under the DCS/Plans and Operations (AF/XO). $C^3$ system replacements are formulated by the Strategic Forces and $C^3$ Division, under the Director of Programs (AF/PRP) with considerable assistance provided from AF/RD and from the Director of Command Control (AF/KRC). Contributions to force planning by the R&D community, however, have been limited: ROCs have been used as one source of new system concepts, Directorate of Planning, Programming and Analysis (AF/RDX) has assisted in costing out the projected systems designated by the force planners, and AF/RDQ has contributed data on candidate systems and has provided some advice concerning technical feasibility.

Unlike most directorates contributing to the EPA, AF/XOX and its parent DCS largely serve the Joint Planning System, not the PPBS.[10] One of its central functions is the annual review and updating of the USAF Objective Force,[11] a planning product which plays a major role in shaping AF/XO activities and attitudes. The Objective Force contributes directly to formulation of JSOP II, which presents the JCS recommendations to the Secretary of Defense and the President on the force levels "required" to meet "national objectives," recommendations that are unconstrained for the most part by resource allocation policies. POM and EPA force replacement plans are based largely on assessments used in shaping the USAF Objective Force.

[10] Appendix A contains a discussion of the relationship between the Defense PPBS and the Joint Planning System used by the JCS.

[11] Assembly of the Objective Force is accomplished by the Deputy Director of Plans for Force Development (AF/XOXF) within AF/XO with the advice of the Force Structure Committee, Air Staff Board.

Beginning with preparations for the FY 1978-1982 POM exercise, the R&D community has attempted in different ways to increase its interaction with the future-force-planning process. Staff members of Headquarters AFSC's DCS/Development Plans briefed the Hq USAF force planners on the feasibility of different development options for particular mission areas in relation to potential resource constraints. Air Staff PEMs and program officers responsible for specific follow-on system concepts reflected in the current EPA have been examining alternative technology efforts which could contribute to attainment of these systems. As yet it is unclear whether these efforts can have any significant impact on the shaping of Air Staff views concerning future capability objectives. (More will be said about this issue in the chapter that follows.)

Another potential source of guidance to the R&D community is the Joint Chiefs of Staff (JCS) planning document, the Joint Research and Development Objectives Document (JRDOD). Although billed as a long-range planning document, it actually deals with system requirements based on shorter-term criteria. The JRDOD develops military objectives from the study of present and projected threats and capabilities. From these objectives the JRDOD predicts future deficiencies and, within 13 functional areas, adjudges these deficiencies as either (1) critical, (2) high priority, or (3) priority. The document does not contain cost projections.

The Air Staff coooperates in the formulation of the JRDOD through the Director of Doctrine, Concepts, and Objectives (AF/XOD) after drafts are circulated and reviewed throughout the Air Force commands and Air Staff. The JRDOD contains more objectives relating to the Air Force than to the other services, and sources in the Air Staff indicate that the Air Force makes more use of the document than do the others.

### Air Staff Planning Functions for 6.2 and 6.3 Programs

Air Staff planning functions differ between 6.2 and 6.3 categories in accordance with Air Force regulations and guidance issued by the Secretary of Defense. For example, OSD planning guidance for the next

two fiscal years has specified the overall funding levels which AF/RD must allocate for the 6.1 and 6.2 program categories. The purpose is to assure continued vigorous pursuit of technology-base programs, which might otherwise be eroded in times of budget stringency in order to continue work on Advanced and Engineering Development programs already under way. Constrained by this guidance, the Air Staff's planning for 6.2 programs is limited to negotiating with DDR&E the exact level of funding, and evaluating and adjusting Headquarters AFSC's suggested split of the funds among the 11 program elements. Specific plans for the work done within the 6.2 program elements are the responsibility of AFSC.

In the 6.3 Advanced Development category the Air Staff has responsibility for formally initiating or for reviewing and approving specific development programs. Both functions are formalized through periodic issuance of a PMD for each program element. Thus, in addition to allocating resources to it, the Air Staff confirms, if it does not actually set, the subgoals for 6.3 development work. In preparation for this, AF/RD program planners scrutinize each proposed 6.3 program element down to the project level, and in some cases to the task level. New 6.3 program elements may grow out of Exploratory Development projects, result from proposals formulated in AFSC or by contractors, or respond to a ROC. They may also be formulated in DDR&E in response to a requirement imposed by OSD or higher authority. Air Staff PEMs work closely with the sponsoring agency and the program planners in laying out the new program element.

Administratively the Air Staff is free to allocate the 6.3 funds to programs they consider will advance research and development objectives. However, they are constrained on the one side by the policy fence protecting 6.1 and 6.2 money and on the other by the rising costs of systems already in Engineering Development. These systems promise to be even more costly in the long run if they are stretched out; they are therefore programmed to meet specific cost and production scheduling targets. The result is that Advanced Development programs tend to be caught in a funding squeeze. Cancellations,

stretch-outs, or rejections of new 6.3 program elements are the alternative solutions.

The last point should be noted. Once a piece of technology is ready for prototype development or is otherwise ready to stand on its own as a visible 6.3 program element, it may become increasingly vulnerable to the budget squeeze. Unless ample provision is made each year for new 6.3 initiations or alternative means are found for obtaining essential hardware development and testing, the menu of developing systems ten or fifteen years hence could be badly restricted.

## AFSC PLANNING

Until recently AFSC activity has affected RDT&E planning at two levels, both of which are aspects of *functional* planning.[12] As in the case of the Air Staff, AFSC (especially Headquarters AFSC) participates in the management control activities of the PPBS cycle. It is during this cycle that AFSC contributes to the decisions made on current resource allocations among the various RDT&E program elements. At another level, AFSC is also responsible for formulating the actual work goals of its field organizations, the laboratories and product divisions. In this activity AFSC contributes to the identification of subgoals for current technology programs with a long-range development impact.

### PPBS Activities

With respect to resource allocation, Headquarters AFSC, consistent with available higher level guidance, conducts its own iterative POM and Budget reviews, interacting with the corresponding Air Staff group during each exercise. In addition, AFSC shares responsibility with Hq USAF for apportioning the funds to the actual working level once the President's Budget has been formulated and submitted to the Congress. During all three of these resource allocation exercises,

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[12] Recent efforts of the DCS/Development Plans staff to influence judgments shaping the EPA and to communicate results of its Mission Area Overview studies to the Air Force Board Structure could make a contribution to *strategic* planning for the Air Force as well.

AFSC has more control over the funding for 6.2 projects than it does for those in the 6.3 programs. One manifestation of this arrangement is that all 6.2 PEMs are located in Headquarters AFSC.

One of the most influential participants in AFSC's program review process is the Program Evaluation Group (PEG). During the POM, Budget, and Apportionment actions, it reviews the full range of RDT&E program elements and recommends fund allocations for each. Actually the PEG is only an advisory group to the AFSC Council of headquarters general officers, but it is made up of representatives of those general officers (Fig. 6) and its recommendations carry considerable weight. For example, the PEG's initial recommended POM structure for FY 1978-1982 was accepted almost without question by the Council.

The PEG makes funding recommendations for both the 6.2 and 6.3 program categories but the two sets of recommendations are of a decidedly different character.

Prior to PEG review in the spring (Fig. 7), all of the 6.2 program elements and those 6.3 elements under Air Force laboratory supervision have been examined in project, task and (some to) work-unit detail by a panel convened by the Director of Science and Technology. The 6.3 projects included in this group have not been intended for specific system integration and include some of the technical activity which we identified earlier as "knowledge generation." As a result of this prior review the PEG is provided with recommendations for a distribution of available resources among the various laboratory activities for the next fiscal year and for the POM pertaining to the following five years. In former years all 6.2 and 6.3 projects in this review were assigned importance categories (high, medium, or low). In the review conducted in preparation for the FY 1978-1982 POM exercise, priorities were reflected in three alternative laboratory program structures: one to reflect the FYDP and POM guidance and the other two as alternative patterns of resource allocation in the event of either a 10 percent increase or decrease in the expected funding.

Since all of the 6.2 projects have been reviewed together in considerable detail and the funding for these projects is relatively small, the PEG concerns itself only with the total 6.2 year-by-year

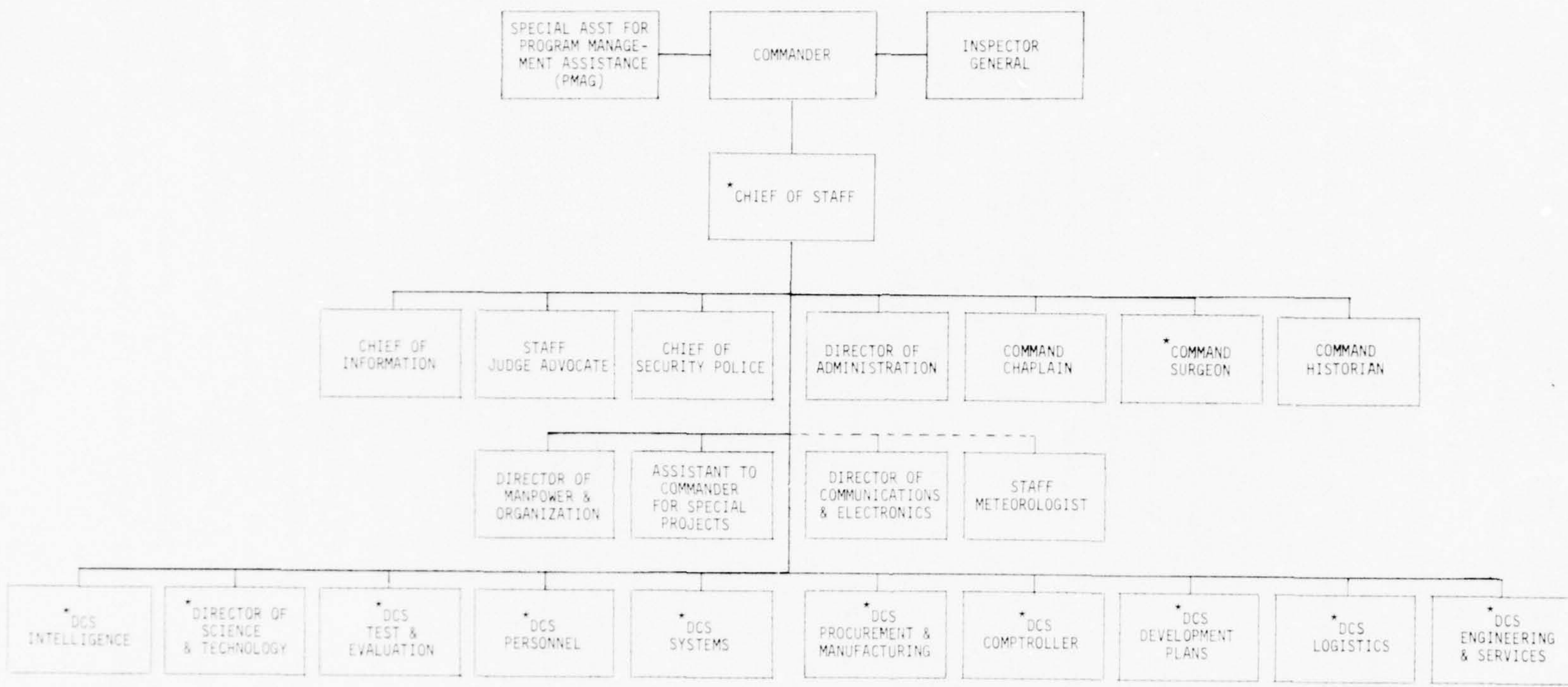


Fig. 6--Organization of Headquarters Air Force Systems Command, April 1976
(Asterisks indicate members of the AFSC Council.)

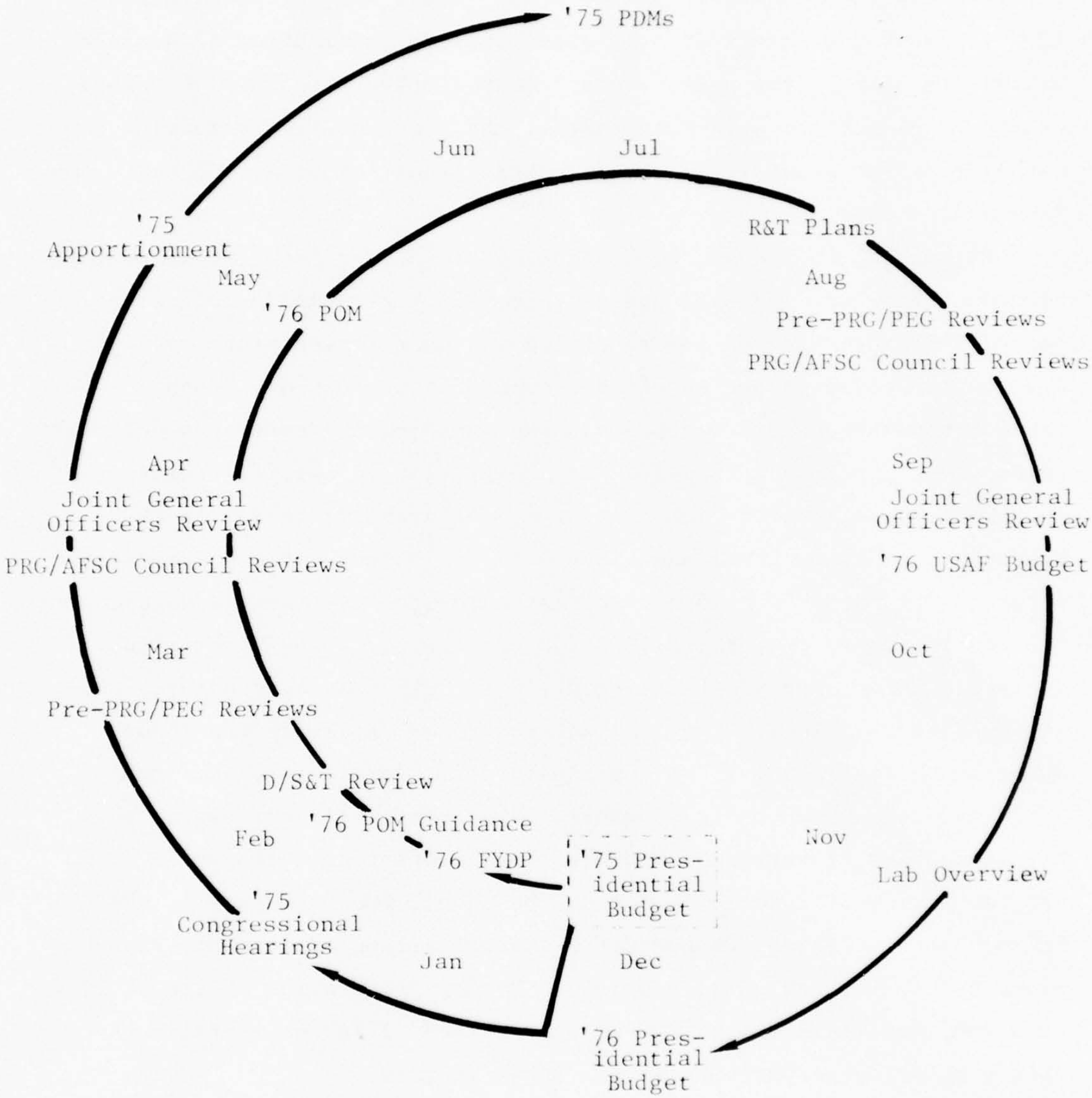


Fig. 7--Program reviews and iterations associated with the Defense PPBS planning cycle, e.g., Calendar Year 1974

allocation, relative to expected fund levels for other program categories, i.e., 6.1, 6.3, 6.4, 6.5. The 6.3 program elements, on the other hand, receive much larger funding for a comparatively limited number of projects and are considered alongside all others in this

category for the first time by the PEG. Hence, PEG deliberations for the 6.3 program elements in some cases include examination of project activities down to the task levels. They involve such considerations as the origin of the work requirement, the phasing of contributing technical efforts and milestones, contractor performance, and past fund utilization.

Recommended 6.3 resource allocations resulting from the laboratory program review are reviewed again by the PEG. Recommendations with regard to the funding of the remaining and much larger proportion of 6.3 program elements are obtained from AFSC's product divisions.[13] These organizations are responsible for managing the contracts under which development work intended for integration in specific future systems is done. After brief review by the appropriate DCS in the Headquarters, their recommendations are considered by the PEG in comparison with the FYDP or other current base-line estimates and guidance.

During these resource allocation exercises, fallback positions are created for each program element in anticipation of possible funding cuts or additions. The fallback positions influence the final apportionment of funds after the President's budget has been formulated and been acted on by Congress. They can also prove useful in the successive iterations which sometimes characterize the RDT&E program reviews. Especially during the annual POM formulation, the PEG may be asked to recommend different variations of fund distributions before the review is complete. During preparation of the FY 1976-1980 POM, for example, the PEG worked on five different iterations affecting selected portions of the RDT&E program.

Each set of PEG recommendations, usually made with the benefit of continued interaction with Air Staff RDT&E program planners, is submitted for review by the AFSC Council. That body reviews the allocations among all program elements but seldom considers individual projects. Its consideration of technical RDT&E issues is limited

[13] The product divisions include Aeronautical Systems Division, Electronics Systems Division, Space and Missile Systems Office, Aerospace Medical Division, and Armament Development and Test Center.

primarily to program elements receiving major increases or reductions, those designed for cancellation, and project plans on which AFSC and the Air Staff disagree. At other sessions the Council also gives considerable attention to management issues, i.e., how proposed funding affects facilities and manpower utilization within the command.[14] Upon completion of the Council's reviews, the AFSC position is communicated formally to the Air Staff, and a joint review of the respective Air Staff and AFSC positions on program elements at issue may be held with the Air Staff's AF/RD directors.

## Identification of Subgoals

The planning of the actual development work is a separate process from the PPBS cycle. Still, these two types of planning actions do influence each other. In the recent past the laboratories have issued their annual plans for 6.2 and 6.3A programs[15] after the POM actions and about the time of the Budget submission to DoD (Fig. 7). Thus, the plans may be influenced in the program year and the one following by any fallback positions taken during the POM actions. Higher headquarters' reactions to the plans will in turn influence apportionment within the laboratory for the program year as well as the initial POM iteration for the coming year. However, the decision authority granted the Laboratory Commander offsets to a considerable extent the potential inherent in the repetitive PPBS-related review process to impose inflexible goals on the technology programs. He is authorized to shift money among different 6.2 projects (all within the same program element) unless constrained by higher headquarters (sometimes influenced strongly by DDR&E); the nature of tasks and work units undergoes

[14] Exploratory Development (6.2) program elements incorporate funding for the operation and maintenance of the Air Force laboratory which corresponds to each of the elements. This overhead funding includes salaries for the civilian personnel employed by the laboratory. Some Management and Support (6.5) program elements are devoted entirely to the support of AFSC facilities.

[15] Projects labeled 6.3A are those Advanced Development projects that are not linked to development of a specific system.

considerable change from year to year even though project designation and funding may remain fairly stable.

The goal-setting process for 6.2 and 6.3A activity culminates in the laboratories' *Research and Technology Plans*. Each plan consists of brief technical descriptions of all work efforts proposed by that laboratory for the coming year and beyond, accompanied by administrative estimates of the appropriate funding, manpower, and resource allocations. Organized into general technology or operational goals, called Technology Planning Objectives (TPOs), the individual development projects and tasks are designed by the scientists and engineers of the laboratory. All 6.2 work will be part of a single program element while 6.3 work related to a particular TPO may represent more than one program element. The project proposals are subjected to successive levels of review within the laboratory before being incorporated in its plans.

Formulation of the *Plans* is accomplished largely by the individual scientists and engineers, who propose specific technical activity within the technology areas encompassed by their respective laboratories. The proposals are based on their knowledge of the state of the art and the laboratory's perceptions of future Air Force needs as derived from a variety of written guidance statements. These include two documents prepared specifically by AFSC to assist the laboratories: *Technical Needs* (TN) consists of a series of statements issued by the product divisions describing technological problems encountered in system development and needing concentrated research or development efforts; the *Technology Planning Guide* (TPG), a document prepared in Headquarters AFSC, identifies needed advances in technology for each Air Force mission area and desired mission capabilities.[16]

[16] The forthcoming edition of this annual publication will include a section, Development Goals, prepared by the DCS/Development Plans. This section is based on systematic examination of each Air Force mission area in terms of expected threat, current and programmed capabilities, relevant ROCs and user views concerning capability objectives and capability deficiencies, relevant 6.2 and 6.3 programs under way, relevant future system/component options, projected funding constraints and resultant issues (Mission Area Overviews). Development Goals, currently 46 in number, have been identified in all mission areas.

The work proposals usually are made in the context of ongoing technology programs and, therefore, often outline logical follow-on activity based on the proposer's assessment of the likely technical payoff versus the risk.

The laboratory management adjudges the proposed projects on the basis of its own view of payoff versus risk, relative to the laboratory's assigned principal mission and the scope of its responsibilities. In addition, these decisionmakers must satisfy such administrative concerns as the desirability of full utilization of its facility, the balance of contract versus in-house work, and the long-term viability of the organization. Other subtle and not-so-subtle influences may come from informal indications of interest by Air Force officials, the salesmanship of the advocates within the laboratory, and advice from other laboratories, users, product divisions, government agencies, industries, universities, and FCRCs.

In the plan, each project selected is accompanied by a list of formal technology requirements to which the proposed work would contribute. These lists can include various sources such as the ROCs submitted by user commands, TNs from the product divisions, Air Staff directives, and the TPG.

As one form of guidance in the formulation and implementation of these plans, Headquarters AFSC conducts a series of formal reviews in which each laboratory's proposed program is reviewed twice each year. A laboratory Overview is scheduled before the final preparation of the plans and is attended by all the laboratory commanders, members of the AFSC staff, and other members of the R&D community in Hq USAF, SAFRD, DDR&E, and the product divisions.[17] This arrangement enables the Overview participants to serve as a kind of Board of Directors for the laboratory program, dispensing guidance concerning the overall shape and balance of 6.2 and some 6.3 activity. Following laboratory submission of the plans, a Technical Review takes place at each laboratory, for staff members of the AFSC Director of Science and Technology and a

[17] Prior to 1975, the Overview followed the technical reviews (as shown in Fig. 7) and aided in shaping the Apportionment of laboratory funds.

few invitees from other parts of the Air Force R&D community with direct interest in that laboratory's output. In Calendar Year 1974, these reviews were attended also by invited members of the DDR&E staff, but this practice has not been resumed. In the absence of any disapproval subsequent to these reviews, the subgoals established by the laboratory are assumed to have official endorsement.

There is nothing really comparable to the laboratories' *Research and Technology Plans* in the product divisions. Since the product divisions have much larger budgets, encompassing many 6.3 and 6.4 program elements, a number of different staff elements in Headquarters AFSC share management responsibility for their work. All work which a product division wants to do in a given budget year and in following years must be proposed, by program element, for higher headquarters review on the occasion of each budget iteration. For program elements and projects already incorporated in the RDT&E program, this is done on a Program Element Summary Sheet, which indicates the origins of the program element, describes each incorporated project and its goal, and gives its scheduled milestone. Project information includes descriptions of contracts and contractor performance to date and a profile of projected funding requirements for each fiscal year until anticipated completion. Relevant data as to intended system integration, initial operational capability (IOC) of the complete system, technology problems anticipated in achieving the system, funding and scheduling problems experienced in the past, etc. are also shown.

Approval or disapproval of part of proposed 6.3 work is reflected in the PMDs issued by the Air Staff. The guidance contained in these directives is then transmitted by Headquarters AFSC to the responsible product division together with elaborating and complementary instructions. The regular occasion for this is at the beginning of the program year, soon after Apportionment review. But initial PMDs authorizing the start of a new 6.3 program element or project can be issued at any time. In addition, program changes may also be instituted at other than the beginning of the program year. One source estimated that each 6.3 program element was affected by about three different PMDs per year.

In any event, all active 6.3 project goals must obtain explicit approval by the Air Staff and are the subject of written guidance directives, by program element, from both Air Staff and Headquarters AFSC.

The only management document linking technology objectives with specific 6.3 (and other) work is the semiannual Planning Activity Report (PAR) compiled by the DCS/Development Plans, Headquarters AFSC. However, as presently structured, this document merely describes work already under way, and its so-called "planning objectives" are written largely to place current development projects in the context of their mission-area contribution. Intended primarily to inform the Defense R&D community at large of development activities under the supervisory responsibility of the compiling staff section, the report is not intended to provide other elements of AFSC with program guidance or to provoke program change proposals. A version with budgetary information removed is also made available for review by defense contractors as a potential source of guidance for their independent corporate research and development activities (IR&D).

Influence on Decisionmaking

One important task of decisionmaking is to reconcile the annual programming and budgeting process with development activities that in some cases take longer than a year. Long-range development cannot be divided naturally into neat year-long projects. Yet the Federal Government's resource control mechanisms, of which the PPBS is a vital element, requires annual work authorization and fund appropriation based on justification of proposed annual effort. From a developer's viewpoint, 6.2 and 6.3 work involves a commitment to pursue a technology until its value in satisfying a particular future capability goal can be clearly determined. To some extent the RDT&E program planning documents, i.e., POM, Budget, etc., indicate this commitment by including a five-year funding projection for all current program elements, thus giving visibility to the near-term development funding implications of current program decisions.

However, other factors influence the eventual appropriations going to various projects. An unexpected technological problem or a

delay in letting a contract or grant can affect the continuity of funding. For example, although the time needed is often less, it can take as long as 18 months to receive the necessary approval from the Office of the Secretary of the Air Force to let out a contract of over $100,000. Contract overruns or other unexpected expenses influence the eventual funding distribution. In these situations, the more immediate funding considerations have to be dealt with--sometimes at the expense of particularly desirable technical efforts. In addition, the nature and magnitude of defense contractors' independent research and development (IR&D) exert strong influences on what the Air Force eventually commits to a particular line of technology development. The total amount spent on IR&D each year is comparable to the Air Force's combined 6.2 and 6.3 budget,[18] and if a contractor decides to expend considerable effort on a particular technology, the Air Force may elect to reduce its own activities in that area and use the resources previously estimated for it on another line of development.

Another factor which influences 6.2 and 6.3 program decisionmaking, in the absence of official priorities, is the role of politics. Since its funding and program are subjected to so many levels of review, a project is examined in the light of many different viewpoints and preferences. For a 6.2 project, the reactions of the successive reviewers within the laboratory are usually what is of the most immediate importance; and there is some tendency, as a result, to tailor research proposals to the biases of laboratory management. However, the participation of other members of the R&D community in the review of a laboratory's proposed plans injects still other viewpoints into the process

[18] During FY 1974, for example, the total DoD share of contractor IR&D costs accepted by the Federal Government was $457 million (Statement by Comptroller General Elmer B. Staats before the Subcommittee on Research and Development, Committee on Armed Services, U.S. Senate, and on Priorities and Economy in Government, Joint Economic Committee, September 17, 1975). The combined Air Force 6.2 and 6.3 program cost for that same year was approximately $656 million (Congressional Record, Senate, October 11, 1974, S19088-19090). Since many of the same contractors do development work for more than one of the services, a precise Air Force share of the IR&D work supported by DoD cannot be provided.

and tends to influence laboratory judgments. For example, the one-time inclusion of DDR&E representatives in the Technical Reviews had a prompt impact on laboratory activities, since some DDR&E participants, after their visits, addressed written questions on the content of the proposed plans for laboratory response. Particularly influential in shaping laboratory programs are the technical views of the SAFRD and the Deputy Director (Research and Advanced Technology), DDR&E.

Because 6.3 development efforts receive closer scrutiny at the higher levels of the Air Force and Defense R&D communities, politics plays perhaps an even greater role in 6.3 program decisions. For example, it is well recognized that certain well-supported program elements have powerful, high-ranking champions. This kind of influence operates indirectly in the PEG reviews and is brought to bear more pointedly in subsequent general-officer reviews, both in AFSC and the Air Staff.

AFSC's planning activity is also influenced by the need to reach a consensus on the coming year's planned expenditures. Some give and take is needed among proponents of the various RDT&E program elements in order to reach agreement within the limits of formal programming guidance. The OSD funding fence for the 6.2 program establishes an overall resource allocation, but the actual funding distribution among the various laboratories is determined and adjusted during the review process which follows (Fig. 7). For example, a cut in 6.3 program funding might result in a decision to continue a particular technology project under the 6.2 program. In anticipation of this kind of possibility, the laboratories do some unofficial assigning of priorities by generating fallback positions for project and task funding. In the case of 6.3 program elements, members of each review body within AFSC represent their office's own subjective priorities and bargain accordingly. For example, in preparation for the PEG reviews of the FY 1977-1981 POM submission, members of the DCS/Development Plans staff ranked all 6.3 and 6.4 program elements by mission area and all projects within each program element. Those given the lowest ratings became bargaining chips in negotiations for a budget all PEG members could agree on.

In reality, however, the PEG can hope to influence only the smaller development programs. Program elements with high-ranking champions in the Air Force or originating through formal directives from DDR&E or higher authority usually receive the highest priority. For all practical purposes this leaves only a small part of the 6.3 program that AFSC and the PEG can influence.

### AFSC's Other Roles

In addition to the long-range actions already discussed, AFSC has another function in the long-range planning process, that of technical adviser and generator of data for decisionmaking. Although this function is performed largely through AFSC's day-to-day management of research and development, it is also evident in other AFSC activities which eventually impact on long-range planning. Through these activities AFSC provides the Air Force with some of the technical analyses utilized by the highest-level R&D managers in making program decisions. These inputs take various forms and originate both from Headquarters AFSC and from its laboratories, product divisions, testing centers, and special offices.

The function of technical expertise is readily apparent in the laboratories and product divisions. These units are responsible for supervising technology development activity and keeping up with the emerging state of the art. In fact, some laboratories have been assigned as "focal" laboratories to keep informed on all R&D in selected technologies throughout government and industry. The Air Force also employs laboratory personnel to review and evaluate IR&D work and to participate in the periodic DoD and Air Force overviews of particular areas of technology. The latter activity often includes authorship of working papers prepared for the overviews.

Headquarters AFSC also evaluates ongoing technical efforts. For example, Headquarters AFSC is responsible for monitoring the IR&D work intended to advance technical competence and encourage innovation and competition among defense contractors. Congress has provided a check on how these funds are spent by requiring that companies with

annual contracts of over $2 million submit written technical plans and provide on-the-site reviews at least once every three years.

In addition, Headquarters AFSC sponsors mission analyses to aid in RDT&E planning. These studies evaluate the functional needs and specific technological alternatives projected for selected mission areas. They are intended to identify the most promising system candidates for providing essential operational and support capabilities. Mission analyses are conducted by study teams assembled ad hoc from individual Air Force, FCRC, and contractor personnel with expertise in the particular mission or technology area at issue. At present, about four to six analyses are conducted per year.

# IV. AIR FORCE VS. IDEALIZED DEVELOPMENT PLANNING

The idealized concept of long-range development planning described in Chapter II encompasses both strategic planning and functional technology program planning. Moreover, as we have seen, development planning should attempt systematically to reduce and deal with the different kinds of uncertainties inherent in future-oriented policy judgments. In this chapter, therefore, we will critically examine current Air Force practices to see how well these ideal features are reflected. We will also compare Air Force practices with certain features of industrial R&D planning. Our discussion will follow the pattern of the planning process given in Fig. 2 (p. 17).

These analyses are made, however, in full recognition that the Air Force is constrained in ways unique to its status as a military service in the Department of Defense. To make comparisons with the idealized conceptions more meaningful, therefore, it is useful first to summarize some of the dominant features of the Air Force's relationship to other administrative entities which affect its current policy and program decisions.

## CRITICAL AIR FORCE RELATIONSHIPS

Administratively, the status of the Air Force is analogous to that of a major product division in private industry. The relationship of the Chief of Staff to the Secretary of Defense and the President is similar to that of a division vice-president responsible to a group executive vice-president and the corporation's chief executive officer. Thus, whereas the Chief of Staff is responsible for strategic planning with respect to Air Force activities, he is also subject to the strategic policy decisions and to the management control system (PPBS) and related functional planning tasks imposed by the Department of Defense. For example, the POM, Budget, and Apportionment exercises conducted annually within the Air Staff are a part of the DoD management control system. So are the program-accounting and program-changing procedures associated with the FYDP.

The management system exercised within the Air Force is an integral part of that established by DoD. It too is expected to be responsive to the policy decisions resulting from strategic planning done for the Secretary of Defense. Stated differently, the Air Force Chief of Staff's strategic planning is expected to be responsive to that of the Defense Secretary, and the Air Staff's management system and functional planning are intended to flow from it. Thus, such annual documents as the Secretary's Planning and Programming Guidance Memorandum (PPGM), which conveys instructions to the services for structuring their POMs, present policy decisions which affect both the Air Force's strategic and functional planning.

The Air Force is subject also to policies emanating from strategic planning at higher levels in the Executive branch. The President's Office of Management and Budget determines annual budget ceilings for each of the different executive departments and periodically updates its estimates of funding available during the coming program year. In the process, budgeting guidelines that are more closely differentiated are developed to help shape resource distribution within the departments. Other policies and goals affecting the Air Force are established in the President's National Security Council. For example, the national positions arrived at in preparation for the Strategic Arms Limitation Talks (SALT) establish guidelines for future development of strategic weapons and supporting systems. Similarly, policy decisions to furnish specific kinds of arms or support capabilities to another country can cause alterations to Air Force weapon inventory and procurement goals.[1]

Finally, Air Force planning activity like that of the other military services is constrained by the role of the Congress. There is no situation in private industry analogous to the budgetary influence regularly exerted by the Congress over the defense establishment.

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[1]A detailed and insightful description of the budgetary interactions between the Department of Defense and various White House agencies is presented in Richard Burt, *Defence Budgeting: The British and American Cases*, Adelphi Paper No. 112, The International Institute for Strategic Studies, London, 1975, pp. 12-15.

Through its control over the purse strings, Congress can overrule and alter individual programs planned by both the Air Force and the Department of Defense. The annual Congressional authorization and appropriation requirement to which the defense budget is subjected, in effect, exposes Air Force programs to critical reviews by two different legislative committees[2] in each house of Congress, and in some years these can represent four distinct wills concerning specific program proposals. Moreover, with a review of each program several times a year, a service's planned multiyear program may receive favorable treatment one year and be sharply criticized and curtailed the following year. Demands are created, therefore, for year-to-year functional planning that can cope with occasional changes in funding and with the preferences of individual critics.

## STRATEGIC PLANNING IN THE AIR FORCE

As compared with functional program planning, strategic planning should be oriented more to the future and need not necessarily reflect current program management concerns. As we have seen, strategic planning should reflect uncertainties and should proceed despite incomplete and imprecise data. It should encourage creativity and explore new concepts. It should neither be constrained by current programs and practices nor standardized with respect to methodology and data inputs. Though it need not be accomplished by a permanent special staff, strategic planning should be performed by individuals who are separated, even if only temporarily, from current program-management functions. Top-level management should be involved, but the line managers of the organization's functional elements should not necessarily participate directly.

Within the Air Force, strategic planning is properly a function of the Air Staff. Only the Air Staff has the direct and frequent contact with Air Force top-level management and the awareness of the full range of interrelated Air Force program responsibilities that are

[2] In the future, Air Force programs may also be reviewed annually by yet another legislative group, the Congressional Budget Office.

needed for strategic planning. However, the Air Staff's performance in this role varies markedly from the ideal strategic planning conception.

Identifying Strategic Goals

At present the only formal setting of future Air Force goals accomplished by the Air Staff occurs during the formulation of the POM and EPA. In the former document, annual goals are set for each major Air Force program, element-by-element, for the next five years. The EPA sets forth annual force and major support-system goals for the six-to-fifteen-year period. Most Air Staff directorates participate in POM formulation, and several directorates contribute to the EPA. Both documents represent fully coordinated Air Staff positions, and both are reviewed within the Air Force Board Structure before their approval by the Chief of Staff.

However, neither document reflects the kind of creative, problem-oriented, special-staff analysis advocated for an organization's strategic planning. Both result from routinized functional-staff inputs, e.g., force projections based on USAF Objective Force, linked to standard threat projections and current national security policy directions. The POM projects forward from the currently approved programs and, aside from Program 6 (RDT&E), the projections in most program elements represent little more than incremental modifications of existing activities. EPA goal descriptions are limited to major weapon and support systems and are practically one-for-one, modernized replacements for the systems in currently approved programs. For example, when developing future requirements for new tactical fighter systems the following approach was used. The average replacement goal for fighters was assumed at ten years;[3] thus, as fighters with a particular capability, such as night/all-weather, close air-support, or air-to-air combat, reached the ten-year mark and were designated for replacement, a new fighter aircraft partially optimized for each particular phased-out capability was introduced into the force structure.

[3] Other categories of aircraft reflected in the EPA have replacement goals of different duration.

The methods, format, and content of these two goal-setting documents are more akin to functional planning and management control systems than to strategic planning. They project into a predictably uncertain future system concepts and activity images that are cast precisely in the mold of current programs. For the most part, current policies and operating conditions are assumed to continue through the planning period--even the long-range planning period. As the products primarily of directorates with responsibility for current program management, these documents are shaped by staff members who have particularly strong incentives to emphasize the rationality of and support for current program goals.[4] Thus, new elements are sought to plug up "deficiencies" identified with current program criteria, perhaps at the expense of overlooking new and imaginative candidate goals.

Particularly lacking in Air Force strategic planning is a corporate listing of the future operational and functional capabilities that are needed, a listing that would correspond to the product-line goals that are used as the base for R&D planning by industrial organizations. The EPA provides a limited and highly selective listing of desired systems to give some of the needed capabilities, but even the descriptive material accompanying this listing does not always make explicit the operational or functional goals intended. Moreover, the EPA listing is far from comprehensive as a statement of overall Air Force product-line

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[4] The Air Force EPA has been structured according to instructions issued by the Assistant Secretary of Defense (Program Analysis and Evaluation) and is assembled principally by AF/PRP, AF/XOX, AF/RDQ, AF/RDX, AF/PRC, and the Director of the Budget (see Fig. 5). Of this group, only AF/XOX is without program responsibility, although it contributes directly to the shaping of strategic, general purpose, and airlift forces (Programs 1, 2, and 4, respectively). Primarily, however, AF/XOX contributes to the Joint Planning System. In addition to building the USAF Objective Force, it also responds to policy proposals and problem assessments from the Joint Staff, outlining positions designed to protect Air Force corporate interests in policy issues that range from selecting personnel to command joint schools and commands to the operation of U.S. military installations on territories of foreign governments. The staff elements may also initiate explorations of Air Force positions on future problems that the JCS or the operational commands (all of them under JCS direction) are expected to confront.

needs. Neither does it represent a systematic, imaginative assessment of long-term organizational direction, one that explicitly accounts for the uncertain threat environment, strategic context, and operational roles inherent in such a long-term future.

The Directorate of Doctrine, Concepts, and Objectives (AF/XOD), the organization in the Air Staff whose charter provides specifically for conducting long-range planning, is the organization corresponding most closely to the corporate planning staff in civilian industry, but it does not contribute to either the POM or EPA. Its incentives and reward structure theoretically should encourage creative and innovative work, but it is asked only to coordinate formally on the proposed texts, as are all other Air Staff directorates. As yet it has played no role in structuring the EPA and has made no substantial inputs to its goal-setting content.

Until 1972, the directorate periodically published an extensive description of possible long-range Air Force operating environments and capability goals. This publication, *USAF Planning Concepts*, was deactivated largely because there was such pressure to coordinate each version among all other Air Staff directorates that some of the publication's more imaginative and innovative passages were eliminated. The coordinating agencies were concerned that concepts proposed for the future might be interpreted as casting a bad light on current program goals. AF/XOD is now developing a successor to *USAF Planning Concepts*. The new document, based on a careful reappraisal of the requirements for long-range objectives and experience gained in conducting a series of long-range projects such as Project New Horizons II, will present a comprehensive set of Air Force long-range capability goals that address needs ten or more years in the future.

The Air Force search for a more appropriate alternative to the EPA as a statement of long-range goals, however, raises the question of whether AF/XOD--or any other directorate in AF/XO--is suited to perform the Air Staff's strategic planning functions. Even though AF/XOD is charged with long-range planning responsibility, it is routinely assigned ad hoc project responsibility for current program issues as well as for controversial policy positions. Moreover, it

has Air Staff responsibility for current USAF and joint doctrine development and is routinely tasked with exploring the doctrinal implications of operational and support program proposals initiated by other Air Staff directorates.

Although the involvement of other AF/XO directorates with JCS matters may suggest a correlation with strategic planning, they, like AF/XOD, have responsibilities that hamper their capability to do strategic planning of a corporate nature. While the identification of strategic goals relates in some ways to JCS interest in military capabilities and strategy, corporate strategic planning also involves systematic analysis of (1) the resources that may be available in the future and (2) various allocation policy alternatives that may be pursued. The methods involved bear little similarity to the routine production of staff position papers and current plans. Each of the AF/XO directorates, on the other hand, has routine reporting and document production functions equivalent to those of the program-oriented directorates in other DCSs.

## Assessing Future Resource Limitations

Aside from its portion of the current Five-Year Defense Plan (FYDP), the only official Air Force assessment of future resources is found in the EPA. In response to specific OSD instructions and format, the EPA displays representative fund allocations to cover development, procurement, and operating costs for each of the ten fiscal years treated by the report. These allocations are further subdivided by program into Strategic, General Purpose, and Other.[5] Recent versions of this report have made their allocations from straight-line projections of the Total Obligation Authority (TOA) estimated for the last year of the FYDP. Variations were permitted, within limits prescribed by OSD, for each year and across the ten-year projection period. However, no variations from one year to the next have been considered in

[5]Strategic offensive, strategic defensive, and strategic control and surveillance forces are aggregated in the "Strategic" category. Tactical air and mobility forces are aggregated in the "General Purpose" category.

major funding and no alternative funding levels have been examined to indicate the internal reallocations that would be preferred. Under OSD's guidelines, the EPA simply does not address the possibility that patterns of fund distribution quite different from the current one may occur in the extended future, the time-frame of the document.

The EPA also displays projected forces by squadron and/or UE levels in the different mission categories. With few exceptions these also have been "straightlined" from the last year of the FYDP. The inflexibility and lack of credibility inherent in these projections are demonstrated by the fact that when the force levels do not change, the operating costs projected for the corresponding years also remain constant. Considerations like inflation rates and variations in operating costs resulting from the integration of new systems into the force have not been factored into the resource projections.

A study which reflects the impact of variable factors like rates of inflation and levels of defense expenditure on future-year resource availability has been produced within the Directorate of Operational Requirements.[6] The cumulative "bow wave" effect produced by such factors operating on currently approved and projected system acquisitions is among valuable points demonstrated in this study. Both this study and its predecessors clearly show the need for hard choices among system goals, for cumulative projected acquisition costs far exceed expected levels of available RDT&E and procurement resources. Although the findings of this study have not gained official acknowledgment by top-level Air Force management, we believe that factors likely to inhibit the future availability of sufficient resources to support *desired* systems acquisition must be given greater visibility in the setting of future program goals.

Determining Priorities and Strategic Policies

With only a limited variety of long-range goals presently developed--and these by methods inappropriate to the uncertainties of a

[6]The office which conducted this study has since been absorbed by a new Directorate of Planning, Programming and Analysis.

distant future--and without a realistic assessment of future resource availability, it is not surprising that the Air Force seems to lack a clear formulation of its strategic policy. At present there is no Air Force statement of its decisions about long-range policy or of its corporate view of future priorities. Particularly lacking are any intimations of its corporate preferences as to the future force and system goals reflected in the EPA. Given the competitive advocacy environment that surrounds the annual quest for defense appropriations, it is understandable why Air Force leaders would not want to publish an explicit set of system and program priorities and thus unnecessarily risk unfavorable program decisions from OSD officials or the Congress. For their guidance, however, functional planners need top management's views of the relative interactions and importance of different capability alternatives and program directions. This kind of corporate guidance would be particularly useful for the planner of long-range development activity, who must anticipate possible resource fluctuations, mission alterations, and policy changes before currently developing technology can yield an employable system.

Our focus, of course, has been on whether there exist formal written statements which could be circulated to appropriate parts of the Air Staff. During discussions with Air Staff officers, we heard frequent expressions of confidence that long-range policy decisions and future priority determinations were regularly being made within high-level deliberative bodies like the Air Force Council.[7] But no one with whom we talked claimed actual knowledge of what these decisions were. One must conclude, therefore, that if policy decisions of this sort are indeed being made, feedback to the staff is not of a sort to provide clear guidance for the staff's future-oriented actions. (One is also left with further concern that, lacking a

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[7] The Air Force Council is at the top of the Air Force Board Structure that was devised to provide corporate review of proposed actions and to recommend related considerations to the Chief of Staff. The Council is composed of all the functional Deputy Chiefs of Staff, the Comptroller, and the Inspector General; it is chaired by the Vice Chief of Staff.

corporately encouraged process for identifying and analyzing possible long-range goals, the Air Force Council itself must base many of its deliberations of strategic policy on the perceptions of future goals of its individual members.)

Strategic policy recommendations do reach the Air Force's top-level management from time to time in the form of special studies and as by-products of current program reviews. Some of the studies with strategic-policy content may be commissioned specifically by Air Force leadership, e.g., New Horizons II and the recently completed study of the Systems and Resources Management Action Group. Others may be done on the initiative of specific elements of the functional staff. Still others may result from Federal Contract Research Center programs under Air Force sponsorship. Reports from these study efforts may gain wide circulation as a result of high-level Air Staff encouragement. Seldom, however, is it made clear whether the policy recommendations of these reports are endorsed or rejected as official expressions of Air Force long-range strategic policy.

Those strategic policy recommendations that stem from the review of current programs usually pass through a series of corporate filters in the Air Force Board Structure. Proposals for program changes and new initiatives are presented by responsible elements of the functional Air Staff to progressively higher-level representatives of several Air Staff directorates sitting as advisory bodies. These bodies include specialized panels (e.g., airlift; tactical; command, control and communications; etc.), across-the-board program management committees, and general-officer program review boards. Future policy recommendations which finally reach the Air Force Council have therefore been subjected to criticism by many people who are connected with the current program. Moreover, in their actual presentation these recommendations may be subordinated to proposals made in the context of modifications to the program. As in the case of the special studies we have just mentioned, top-level management's reactions to recommendations about future strategic policy may also not be made clear to the staff.

One of the main reasons why a systematic means is needed for providing the rest of the Air Staff with a corporate view of direction

for the future is the lack of personal continuity in the Air Staff's top-level management positions. During the five-year period that began with FY 1972, all general officers who had served in DCS-level positions were either transferred to field commands or retired. None moved into higher Air Staff management.[8] With one exception, all of the general officers picked for one of the two top management positions were picked from field commands. Only the top officers in the program-oriented DCSs moved into those jobs from within their functional staff organizations. Within the functional staff organization responsible for force, operational, and policy planning, personal continuity in top-level positions has been extremely limited. Frequent rotation of the AF/XO general officers into and back from the operational commands and the JCS organization has been emphasized to maintain familiarity with problems confronted currently by field organizations. While these practices may be highly desirable for reasons other than their implications for policy continuity, they indicate that general-officer assignment practices (reinforced by periodic Air Force-wide and frequent Air Staff meetings) are designed to assure familiarity with current management issues and near-term program alternatives. They also suggest that continuity with respect to a corporate view of future Air Force directions may have suffered.

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[8] From July 1971 through May 1976, there have been:

o Three different Chiefs of Staff (only the first, General Ryan, was serving on the Air Staff at the time of selection--as Vice Chief).

o Three different Vice Chiefs of Staff (none of whom, thus far, has succeeded to the Chief of Staff position or was serving on the Air Staff at the time of his selection as Vice Chief).

o Four different DCS/Plans and Operations (only two of whom were serving on the Air Staff at the time of their selection).

o Three different Directors of Doctrine, Concepts, and Objectives (none of whom, as yet, has succeeded to higher jobs in the Air Staff).

o Three different Directors of Plans (only one of whom succeeded to a higher job in the Air Staff).

o Three different DCS/Research and Development (all of whom were serving in AF/RD at the time of their selection).

o Two DCS/Programs and Resources (both of whom were serving in AF/PR at the time of their selection).

Several staff officers with whom we talked lend validity to this view by their observations that significant changes in direction did in fact accompany the top-level changes in personnel. Priorities shifted and methods of staff operation changed in response to the preferences of the general officers in charge. Continuity was most evident in--and hence the sense of direction tended to be circumscribed by--the promotion of specific major follow-on weapon systems, e.g., the B-1, F-15, and AWACS. Future policy issues--the degree of dependence on forward bases overseas, the encouragement of remotely piloted vehicles as a possible air-to-ground strike alternative, or the development of improved means for operating in support of foreign allied ground forces--have been pursued less consistently in the same period.

Some of the changing priorities on policy issues obviously resulted in part from policy shifts within the Government and from changes in the international diplomatic and security scene. For example, the transitional phases of the SALT negotiations, the conduct and outcomes of the 1973 Arab-Israeli war, and the termination of U.S. military involvement in Southeast Asia all had rather prompt impacts on the priorities of the U.S. uniformed services.

But the international political trends and technological advances which were highlighted by such events were quite evident well before the events took place. For example, the emerging U.S.-Soviet strategic force balance and growing pressures to limit U.S. defense spending were recognized. So was the growing reluctance of allies to permit U.S. unilateral operations from their bases, and the increasing public disillusionment with U.S. intervention in areas outside Europe.

Rather than adopt policy directions for the future in abrupt response to current policy shifts within the Government or to top-level Air Staff personnel changes, the functional staffs should be guided by a more stable corporate view based on a systematic planning-staff assessment of such trends. Assessments of significant trends, coupled with systematic exploration of the consequences of alternative organizational policies and leavened by the Air Force Board Structure's continuity of management outlook, should engender an underlying

corporate sense of direction for the future that can absorb and benefit selectively from the influences of occasional events. Moreover, this sense of future direction should be imparted to appropriate elements of the Air Staff to help guide the functional planning that can have an impact on future capabilities.

## ORGANIZATIONAL ALTERNATIVES FOR STRATEGIC PLANNING

Given its real property investment, its commitments to multiyear development programs, its responsibility for operating and maintaining technically sophisticated weapon and support systems, and its operational responsibilities at home and overseas, the Air Force is a complex enterprise with continuing needs for corporate strategic planning as demanding as those of any industrial company in existence. As we have seen, strategic planning is a corporate management function; it should explore alternative potential directions for the entire organization, directions that reflect the functional concerns of all parts of the organization. Strategic planning should not be hamstrung by program protection or bureaucratic rivalries that stem from contention between different functional elements of the organization. It should encourage systematic speculation and analysis designed to illuminate the probable consequences of alternative policies rather than lead necessarily to one preferred outcome. For these reasons the typical corporate planning staff in industry is usually quite small and located as part of the chief executive's personal staff. How, then, should the Air Force's strategic planning responsibility be organized?

Alternative locations for an Air Staff organization devoted to strategic planning are as follows:

- A staff element in AF/XO
- A new staff element in a different DCS
- A new element in the Chief's personal staff
- A new staff element in the Office of the Secretary of the Air Force

Although the Air Staff's current charter for long-range planning activities is located within AF/XO, that organization is not particularly well suited to perform corporate strategic planning. AF/XO's functions in connection with international policy issues, operational capabilities, and future force structure certainly make it a repository for data vital for strategic planning, and it is clearly the Air Staff's planning organization--at least for near-term, political-military concerns. However, in the current climate and that of the predictable future, one of severe resource constraints and a politically responsive national security apparatus, the most pressing demands on the skills and imagination of Air Force leadership are likely to be those of corporate management, not military strategy. Air Force strategic planning should therefore be conducive primarily to sound corporate management; it need not necessarily be embedded in the JCS-oriented planning structure of AF/XO, which evolved under the influence of an earlier and different DoD environment.

More to the point, the prevailing ethos, the bureaucratic incentives, and the cognitive processes operative in activities central to the AF/XO mission are not appropriate for strategic planning in the corporate management sense. AF/XO's products are frequently designed for advocacy within the JCS arena and motivated by a concern for doctrinal integrity. Its staff procedures are designed to insure tight discipline relative to the current party line, both within the Air Staff, in its intercourse with other DCSs, and outside the Air Force, in its relation to the other military services. Above all, the policy positions developed by the AF/XO staff are strongly influenced by the Air Force's currently approved force program. For example, in the early 1960s several parts of the AF/XO staff opposed the adoption of the counterforce concept, in part because they perceived a threat to the Skybolt air-launched missile system in the concept's emphasis on (1) minimizing collateral damage and thus (2) holding populated areas hostage as a coercive device. AF/XO staff views on policy issues are dominated by concern that the Air Force's position on the force posture will be eroded, the internal

consistency of current Air Staff views weakened, and the integrity of this position opened to challenge.

Given Air Staff structure and its well-established procedures for coordinating staff positions, it is virtually impossible to advance a controversial or imaginative concept without solid DCS support. Thus, were long-range strategic planning functions to be performed within AF/XO, its products would have to pass successfully through a filter of the kind of attitudes and considerations we have been describing. While such a filter may be an important contributor to well-integrated programming and the good intrastaff communication necessary to near-term functional planning, it tends to stultify and constrain long-term analyses.

If a corporate strategic planning staff were established within the functional staff of a DCS other than AF/XO, it would be exposed to many of the same operational problems that uniquely constrain long-range planning within AF/XO. The output of the staff would be directly associated in the first instance with a particular functional DCS and it would be difficult to represent the product as having Air Staff-wide credibility. For this to be achieved would require subjecting the planning staff's output to formal interdirectorate coordination. Similarly, and a prerequisite to the staff coordination process, the strategic planning output would first have to obtain solid backing from the parent DCS, thus incurring the constraint of at least being not incompatible with that staff element's current programs.

In addition to its staff operational similarities to AF/XO, a strategic planning staff located in another DCS would immerse the strategic planning process in an Air Staff element primarily responsible for an ongoing functional program. All other DCSs in the Air Staff are program-oriented--either toward one type of specialized functional program (e.g., system procurement) or, in the single case of AF/PR, the whole range of current Air Force programs. In fact, AF/PR embraces both kinds of functional program responsibility; its DCS is responsible for the five-year programming of all but Program 6 (RDT&E) and is also responsible for managing the installations engineering program. Thus, location of the strategic planning function in a

different DCS would expose the function even more directly than now to the management control influences related to Air Force participation in the Defense PPBS.

If a corporate strategic planning staff were established as an element in the Chief of Staff's personal staff, many of the problems resulting from DCS association could be avoided. The output of the strategic planning staff could have high credibility as representative of the entire Air Staff and equally applicable to all its parts. Moreover, it would acquire prominence by being popularly perceived as having the Chief's interest. Of course, the staff output, instead of being controlled by a particular DCS, might be subjected more directly to the special preferences and whims of the incumbent Chief. But, being free from association with a particular DCS, the output would be removed from bureaucratically inspired program commitments and would be immune from formal staff coordination requirements.

Immersion of the strategic planning function in the Chief's personal staff would yield a number of other advantages as well. In the past a number of special studies dedicated to improved corporate Air Force management have been directed from the offices of the Vice Chief and the Assistant Vice Chief;[9] a strategic planning effort conducted as a proper adjunct to corporate management would benefit from close association with such studies in the future. Similarly, the strategic planning staff would have ready access to the Air Force Board Structure Secretariat, another staff element responsible to the Assistant Vice Chief. Reacting to proposed concepts and policy alternatives for the future is one of the roles which the Air Staff Board and the Air Council are intended to perform, and close association with the Secretariat could facilitate getting planning staff proposals on the agenda of these corporate bodies. Finally, as the subjects of the strategic planning staff's analyses shifted, it could readily obtain assistance from ad hoc groupings of resource persons drawn from all parts of the Air Staff.

[9] Air Staff Organization Study Group (1958); Air Force Management Study Group (1969-1970); System and Resources Management Alternatives Group (1975-1976).

If a corporate strategic planning staff were established in the Office of the Secretary of the Air Force, the problems resulting from DCS association could be avoided, and many of the advantages resulting from association with the Chief could be realized here as well. In addition, the planning staff would have ready access to the staffs of the civilian officials who are responsible for formulating departmental policy on the management of Air Force resources.[10] The interests of these officials, like those of the Secretary, may be constrained by the management issues of particular concern to the incumbent administration. But their staffs are populated by a number of career officials who represent considerable continuity and long-term interest in the future Air Force.

Locating the strategic planning function in the Secretary's organization is also made attractive by its providing for considerable continuity and planning experience in the planning staff itself. Civilian staff members, at least, would not be affected by the rotational assignments under which Air Force officers serve on the Air Staff. One thinks, for example, of the unique expertise acquired by the Secretary's former Assistant for International Affairs as a result of serving in this capacity for more than 25 years. The methods and cognitive processes needed for truly long-range corporate planning require similarly unique expertise. Management-control competence, on the other hand, is more generally available. Their nurture in an office with greater personnel continuity than is typical among the military sections of the Air Staff would be greatly in the Air Force's continuing interest.

Countering in some measure the advantages of locating a strategic planning staff within the Office of the Secretary of the Air Force would be the unique role of the Secretary. As both the direct subordinate of the incumbent administration's Secretary of Defense and the chief executive of the Department of the Air Force, any Secretary

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[10] Assistant Secretary for Financial Management; Assistant Secretary for Installations and Logistics; Assistant Secretary for Manpower and Reserve Affairs; Assistant Secretary for Research and Development.

will be confronted from time to time with conflicting loyalties. Should such conflicts occur between perceptions of long-range corporate interests of the Air Force and policies affecting short-term interests of the administration, the Office of the Secretary might prove a difficult spot for conducting objective analyses of long-range policy issues.

### A Possible Solution

By creating some civilian positions in a section established within the Chief of Staff's personal staff and by selecting highly qualified persons for those positions, the advantages of continuity for unique expertise could be combined with the desirability of maintaining the corporate planning function within the professional elements of the Air Staff. One of those civilian positions might be designated for the official primarily responsible for the strategic planning function, i.e., the section chief.

A corporate strategic planning staff, so located, would probably generate substantial data unique to its own analytical responsibilities; it would also have ready access to the data and expertise of the Assistant Chief of Staff for Studies and Analysis. Its self-contained expertise could be supplemented to great advantage by a close working relationship with selected outside consultants. For example, it is within the competence of The Rand Corporation to develop a research group especially qualified and specifically designated to provide continuing support to an Air Staff strategic planning organization, should that be desired.

## R&D FUNCTIONAL PLANNING IN THE AIR FORCE

While strategic planning is future-oriented, functional planning is concerned with the formulation of current program goals and the allocation of current resources associated with the management process.[11]

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[11] In this context, "current" refers to those Air Force goals, programs, resources, etc. that are reflected in the Five-Year Defense Plan in effect at the time.

Given the wide range of technical activities embraced by the RDT&E program, current resources must support program elements whose relevance to operational systems is oriented to different time periods. Thus, RDT&E program planners must occasionally resolve conflicts that arise between future goals and the imperatives of current programs, apportioning available resources in the way that will most effectively take care of all needs. "Striking the right balance between strategic and operating considerations," as Anthony says, "is one of the central problems in the whole management process."[12]

Unlike strategic planning, functional planning is plainly evident in the Air Staff and AFSC. Its more routinized nature makes it adapt better to the program management and fiscal accountability climate in which the Department of Defense must operate. As has been discussed in the previous chapter, there are several formal procedures involved in the management control of Air Force RDT&E. The following examines several of these in terms of their contribution to functional program planning.

## Identifying Subgoals for Technology Programs

Ideally, subgoals selected for the Air Force's RDT&E program should be consonant with overall strategic goals. In this section we examine two formal procedures by which Air Force R&D subgoals are identified, in order to determine the contributions of the procedures to goal congruence. The first is the Air Staff's validation of Required Operational Capabilities (ROCs), which constitute a major input into the formulation of Advanced Development (6.3) programs. The second is the AFSC laboratories' development of Technology Planning Objectives (TPOs), organizational devices for developing the laboratories' annual Research and Technology Plans. In their totality the TPOs define the structure of the Air Force's Exploratory Development (6.2) program and relate nonsystem-oriented 6.3 projects to it. We also call attention to staff analytical efforts, instituted for the first time in

[12] Anthony, op. cit., p. 53.

support of FY 1978-1982 POM preparation, which show promise of progress toward a systematic procedure for identifying appropriate technology program goals.

Required Operational Capabilities. Several aspects of the ROC process, described in the previous chapter, make it a good functional planning tool. First, the validation procedures of the Requirements Review Group are intended to protect the Air Force's development efforts from goal mismatch. Since this board is composed of general officers from several key elements of the Air Staff, the resultant requirements must to some extent reflect corporate goals. In addition, the fact that validated ROCs are widely circulated throughout the Air Force makes them a good means of communicating user needs and tacit top management support. This is especially important in an organization as large and complex as the Air Force.

While the ROC process is well suited to the promotion of goal congruence, some problems arise in converting validated ROCs into active RDT&E program goals. *Part of the trouble stems from the fact* that there are too many validated ROCs for limited RDT&E resources and no systematic procedures for sorting out the validated ROCs in order to assure that those outlining capabilities of greatest importance for long-term Air Force goals will be reflected promptly in approved technology efforts. For example, early in 1975 approximately half of the 416 validated ROCs had neither been reflected in approved RDT&E program elements nor funded as part of the annual development program. The Air Staff has proposed a system of placing all validated ROCs into five categories of importance, but conflicting organizational interests and political pressures have interfered with putting this system into effect. Eventually a similar system may provide reliable all-Air Force guidance for the setting of subgoals for the RDT&E programs.

Technology Planning Objectives. The TPOs, under which each laboratory's Exploratory and Advanced Development work is structured, are required by Headquarters AFSC to facilitate management's periodic reviews of the laboratory's ongoing work. A management control device,

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LONG-RANGE DEVELOPMENT PLANNING IN THE AIR FORCE.(U)

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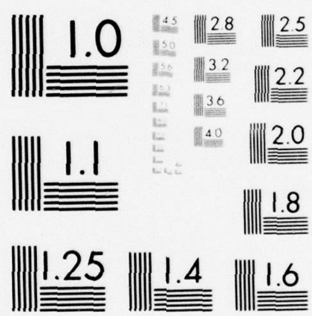

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the TPOs combine similar technical goals and display the correlation between specific work elements and stated requirements, thus enabling reviewers to get a simplified view of a large number of individual work efforts. A different set of TPOs is developed in each laboratory, but Headquarters AFSC instructions require that all TPOs identify goals, supply guidance for several years' work, provide data for program review, and display relevance to formal program guidance.

In practice, the TPO often represents the projection of current research decisions and goals. TPOs are constructed with only a five-year horizon and often reflect the existing organization and technical program of the laboratory. In some laboratories the planning office under the director forms committees with representation from each line division and charges them with the formulation of appropriate TPOs based on existing AFSC guidance and their identification of promising technologies. Other laboratories simply make each division responsible for its own TPO. In sum, each group of TPOs is solely the product of a particular laboratory, and together they do not necessarily reflect a corporate Air Force view of what the technology program should be directed toward.

While the laboratories have been sent many official documents (e.g., TNs, JRDOD, TPG, etc.) intended to indicate the different areas of military technology needing development, little formal guidance has been provided that aids directly in setting priorities for the selection of task and work-unit goals. The TPG's estimates of needed technology advancement have been given prior review by various Air Force organizations including the operational commands, but have not been evaluated in terms of relative importance even within their respective mission areas. In recent years a second portion of the TPG has presented either conceptual system options or, most recently, desired capabilities, but it has represented primarily the views of AFSC's development planning staff.[13] Each TN represents only the

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[13]In its forthcoming edition, this portion of the TPG will be replaced by the DCS/Development Plans' descriptions of Development Goals. Each goal will be discussed in terms of the criteria used to assess

views of a single AFSC production division on a single technology deficiency; all are presented as of equal importance and together they comprise an undifferentiated compendium of possible work. Thus, laboratories are, in effect, encouraged to select their own program goals based on their perceptions of what should be done within their respective technology areas.

Of course, program goals reflected in the TPOs and the Research and Technology Plans can be modified before the Plan for any given fiscal year is actually put into effect. The laboratory Technical Reviews and overviews provide opportunity for this, and the impact of Headquarters AFSC, Air Staff, SAFRD, and DDR&E reactions to the plans is felt during the several months which intervene. Moreover, a laboratory's 6.3 program goals can be affected by guidance contained in PMDs issued to outline the previous year's work in related program elements. The goals of 6.3 programs have recently become subject to potential influence from yet another reviewing agency. AFSC's product divisions have been directed annually to reevaluate, in terms of their potential application in system development, all 6.3 projects in which they have an interest and to assign each project, by mission area, a relative importance (high, medium, or low). Presumably these judgments would contribute to the priorities which the DCS/Development Plans will give them in his subsequent description of Development Goals.

The newly crystalized Development Goals offer a potential, if only a partial, solution to the shortcomings of permitting laboratories to formulate their TPOs around their existing program organization and of relying heavily on a laboratory's perceptions of what its program goals should be. Even with the salutary effects of opportunities for higher headquarters to criticize laboratory plans, the necessity for dealing separately with individual laboratories, hence, individual

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its role in the mission area, and each will be assigned an importance category (high, medium, or low) within that area. In addition, each goal statement will be accompanied by a list of official documents from which its characteristics and importance were derived, e.g., relevant ROCs, DDR&E surveys, TNs, etc.

technology areas, creates a need for a more cohesive, clearly recognized development scheme to which the various technology efforts should contribute.[14] Stated in terms of operational capabilities and system performance characteristics desired for specified mission areas, the Development Goals would, of course, indicate priorities and provide useful guidelines only for those technology projects that could be related to a particular operational mission. While most 6.3 projects could readily be associated with this kind of goal structure, many of the 6.2 projects (in the "knowledge-generation" category) could not. For these latter projects, the judgments of laboratory staffs and current management procedures would be more appropriate. Moreover, the guidance value of the Development Goals, as they are tested and sharpened, would depend on the consistency with which laboratory compliance with these preferences was required.

It is important to emphasize that AFSC's Development Goals do not in themselves suffice as technology program subgoals. To the extent that they are stated in terms of desired operational and functional capabilities, they are similar to the strategic goals which we envision for Hq USAF endorsement. It is in this respect that the Development Goals have utility as guidance for the identification of technology program subgoals. In their present form, however, most of the Goals reflect only current and programmed mission and system concepts, particularly in the context of their stated "criteria for [technology] program assessment." Although they avoid preferred system solutions, some of the Goals describe system performance characteristics desired for a particular mission area. Thus, in terms of the strategic/functional dichotomy, the Development Goals present a mixed bag; like the guidance documents from which they derive their authority, many Goal statements address current capability deficiencies in order to cope with problems perceived for the near-term future.

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[14] This problem has been recognized within AFSC's office of the Director of Science and Technology and has been addressed in part through a series of Investment Strategy exercises, about which more will be said later in this chapter.

New Analytical Efforts. In preparation for the FY 1978-1982 POM exercise, several RDT&E program analysis efforts were initiated which could have a beneficial impact on goal-setting for 6.2 and 6.3 technology development. The Development Planning office in the Air Staff's AF/RDX has begun a series of reviews of technology efforts supporting selected functional areas of Air Force activity. This includes navigation, avionics, propulsion, air-to-air target acquisition and weapon guidance, and other technical regimes. The reviews will involve reviewing relevant ROCs, examining all current Air Force and other DoD projects, evaluating stated deficiencies and technical barriers, and assessing resource requirements.

This office has also requested Air Staff PEMs whose systems are reflected in the EPA to examine alternative patterns of component technology development that could lead to their respective systems. One object is to identify particular technologies on which greater effort would be needed in order to meet capability standards conceived, for example, for a future close-air-support aircraft. Another object is to give earlier visibility to performance and cost tradeoffs inherent in the conceptual systems and thus provide Air Force management with a more realistic basis for establishing current technology and future system development priorities.

Using the aforementioned Development Goals as points of departure, AFSC's Director of Science and Technology structured an analysis of current laboratory program elements to determine how important each is to the attainment of these goals.[15] Different teams of evaluators, composed of laboratory, product division, Headquarters AFSC, and Air Staff personnel, assessed (1) the adequacy of existing technology efforts in support of each goal, and (2) the contributions of each program element to a variety of goals. Existing program elements were assigned composite scores according to their assessed degree of importance to a goal and the assigned relative importance of the goals to which

[15] The initial Investment Strategy exercise was held during June-July 1975. A second exercise, using an improved set of Development Goals, was completed in November 1975.

they contributed. Specific technologies warranting greater effort than currently provided for within a program element were identified and assigned either a greater or lesser priority.

As of this writing it remains to be seen what use will be made of the kinds of information which these analytical efforts produce. They have the potential, however, for making possible a better handling of some of the uncertainties inherent in long-term development strategies and for illuminating the kinds of consequences involved in the goal choices available to technology program planners.

Evaluating Alternative Technical Approaches

Until recently, one of the weakest links in Air Force RDT&E program planning was its evaluation of alternative technical approaches intended to support similar operational or functional capabilities. Before 1975, these comparisons were made largely in the context of the formal program reviews, supplemented by occasional studies of particular technology problem areas and analyses of selected mission areas. Individual participants in the program review process, at its various levels, could make use of these study results in influencing the collective judgment of the reviewing group. But, as we have seen, the formalized, program-element-by-program-element review afforded only limited opportunity for detailed evaluations and instead more usually encouraged concern with resource control factors like contractor performance and funding profiles.

At Headquarters AFSC, at least, this previous situation has been improved significantly. With respect to 6.3 technology planning, in particular,[16] the emergence and maturation of mission-area planning under the DCS/Development Plans has provided a systematic basis for evaluating technological alternatives. All 6.3 program elements pertaining to a particular mission area are examined in relation to each other and in relation to planned Engineering Development and systems

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[16]These comments apply also to the 6.4 and the Operational Development programs, which are outside the focus of our study of long-range development planning.

acquisition activities associated with that area. These program elements are evaluated within an analytical context composed of explicit threat projections, current and programmed capability assessments, operational-command views about future capability needs, and resultant capability development issues. Thus different program elements and other alternative technology possibilities can be compared systematically within a framework of common mission-area association and similar capability objectives.

Mission-area planning provides AFSC with its most detailed analysis of RDT&E goals and program elements. It has provided the basis for two program analysis efforts mentioned previously in the study: (1) the Development Goals used in the laboratory Investment Strategy exercises, and (2) the preference ranking of 6.3 and 6.4 RDT&E program elements and projects to assist in POM formulation. Moreover, in conjunction with the FY 1978-1982 POM exercise, the DCS/Development Plans presented the PEG with a proposed resource distribution by program element to use as a basis for PEG deliberations. A member of that body explained that the funding alternatives based on mission-area overviews provided the PEG with basic negotiating positions; this placed on critical members the burden of offering and justifying a sounder position.

AFSC's recommended 6.3 and 6.4 RDT&E program allocations for the FY 1978-1982 POM, therefore, were based on a rather careful evaluation of alternative technical approaches to like operational and functional capabilities. A similar evaluation underlay the AFSC position developed for the FY 1977 RDT&E Budget the previous October. However, these positions do not necessarily become the Air Force's recommended program allocations. For example, during the second iteration of the 1978-1982 POM, there were 16 or 17 program elements on which the AFSC and Air Staff positions differed substantially. Almost all of these issues were resolved in the Air Staff's favor--despite the lack of a systematic evaluation of alternative technical approaches to given capability goals in the Air Staff's RDT&E programming procedures. Of course, there will be at least two more opportunities for the more

systematically determined AFSC position on these (or other) issues to prevail, i.e., the FY 1978 Budget and Apportionment efforts, but of the three RDT&E budget review efforts, that contributing to the POM is the most elaborate and systematically resolved.

The AFSC's recommended 6.2 program allocations pretty well determine the Air Force position, but here the contribution of a systematic evaluation of alternative technical approaches to given operational or functional capabilities is less evident. One potentially useful analytical framework for such an evaluation has been provided in the Investment Strategy exercise; in this, "intersections" between particular Development Goals and various 6.2 program elements and projects are described. However, the Investment Strategy exercise has not, as yet, been exploited to compare the particular contributions of different projects or prospective projects to a single goal. Instead, it has aimed primarily at giving a comparative rating of the worth and fundability of individual program elements, based on the variety and importance of the goals to which they contribute and on how essential that contribution is.

Of course, a substantial proportion of the 6.2 projects are of so technical a nature that it would be difficult to relate them to specific capabilities. Particularly with respect to operational mission capabilities it would be fruitless to attempt to judge the relative contribution of, for example, many projects in program element 62102, Materials, or 62202, Aerospace Biotechnology. Composed primarily of knowledge generation efforts, projects in these areas of Exploratory Development seldom are linked to particular mission areas. We are informed, however, that Headquarters AFSC is now making a serious attempt to identify a second variety of development goals to which a larger number of laboratory projects might be conceptually linked. Rather than from a particular mission area, these goals would be derived from technology areas and might have utility in several missions, e.g., a goal of a nonflammable hydraulic fluid.

## Allocating Available Resources

RDT&E program planners in AFSC and the Air Staff must parcel a limited budget among a number of RDT&E program possibilities having

capability payoffs anticipated for either the near-term or long-range future, e.g., the 6.2, 6.3, 6.4 distinctions. Given the limited budget levels and the fact that most allocations are made among technology program elements already in existence, the prevalent objective of the program review exercises is to determine funding levels for the coming year rather than to evaluate a program element's future direction. In order to permit major system-replacement programs to proceed at their intended pace in a period of rising development costs, however, a corollary objective is to identify likely candidates for reductions in previously planned funding. For example, during the formulation of the FY 1976-1980 POM, an overall reduction in the RDT&E allocation was accommodated by a cut in the funds for some of the Advanced and Engineering Development program elements. This permitted the work on more immediate systems needs to continue on its original timetable.

Given this concern for identifying soft spots in the current program structure and the program-element-by-program-element review format, described in Chapter III, the principal bases for review group deliberations have been provided by such considerations as the following: whether or not contracts have already been let; whether or not project milestones have been consistently met; whether or not project termination costs would be prohibitive; whether or not a particular project could be stretched out at a lower level of funding without upsetting specific system production forecasts; whether or not Congressional committees had shown interest in or disfavor toward earlier efforts in the project, and the like.

While such concerns are essential aspects of the Air Force's management control function, they can adversely affect long-range technology development if they influence resource allocations without the leavening of a recognized set of goals and priorities. The current lack of such corporate policy guidance limits the ability of the formal review groups to deal explicitly with long-range development issues. A few of the sexier and recognized high-interest future technologies, for example, laser, will be provided for. Moreover, we have been

assured that all participants in the formal reviews are familiar with such things as the major follow-on systems identified in the EPA, the bow-wave problem, and the technology areas that involve major development risks. But, in effect, each review group must work out its own project priorities to accommodate the preferences of its members and of influential officials as well as consider such factors as related technology work being done elsewhere in DoD or through contractors' IR&D. It must also cope with the programming reality that between one budgeting exercise and the next (e.g., between the POM and Budget reviews) unscheduled events like contract overruns or accidental destruction of vital test equipment can alter one's funding priorities.

The review groups in both AFSC and the Air Staff have obtained a new kind of help in the resource allocation functions they performed in conjunction with preparing the FY 1978-1982 POM and the FY 1977 Apportionment. For the first time review groups were able to compare the possible effects of alternate-level funding on the full range of RDT&E program elements. At the request of AF/RD, the staff of AFSC's DCS/Development Plans presented several Air Staff review groups and the PEG with a suggested funding and order of priorities, grouped by mission area, of all 6.3, 6.4 and procurement program elements for three different budget levels. The alternative program levels included plus <u>and</u> minus 5 percent and minus 15 percent of the FYDP funding for FY 1978 and beyond.[17] AFSC's Science and Technology review panel examined 6.2 project funding at FY 1978-1982 budget levels of plus <u>and</u> minus 10 percent in addition to the FYDP level.[18] By having the impact of different resource levels on various technologies displayed, the review groups could determine their

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[17] AF/RD letter to Commander, AFSC, "AFSC Participation in FY 1978-1982 POM Formulation," January 9, 1976.

[18] The Science and Technology panel was assisted in this effort by results of the laboratory Technical Review, conducted in October 1975. At these reviews, the laboratories were required to present their plans for three different budget levels (FYDP and plus and minus 10 percent). The laboratory exercise also proved helpful in apportioning adjustments to the FY 1977 Budget.

program priorities assisted by concrete examples of the kind of project and milestone tradeoffs which would be confronted if overall resource levels were to change.

Different attempts have been made through the Air Force Board Structure to impart a sense of corporate priorities to the allocation of RDT&E resources. Beginning with the FY 1976-1980 POM exercise, an RDT&E Panel was created by the Air Staff Board to review "proposed and established" RDT&E programs, "to assure consonance with Air Force plans, objectives, and missions," and to interface between the functional R&D staff and the Air Force Board Structure.[19] In the Panel's independent review of the proposed FY 1976-1980 RDT&E program, all 6.3 and 6.4 program elements were grouped by related mission area and assigned one of four priority groupings according to each program element's perceived "contribution to national security." In effect, the procedure graded the program element according to the Panel's collective judgment on its vulnerability to funding cuts. The RDT&E Panel has continued to advise the Program Review Committee of the Board Structure and the functional program planners in AF/RD on the relative merit it sees in different portions of the RDT&E program, but for the FY 1978-1982 POM it reviewed only the 6.1, 6.2, and 6.5 program elements. Significantly, the knowledge generation issues relating to the 6.1 and 6.2 programs are issues which the RDT&E Panel is probably least qualified to appraise. The 6.3 and 6.4 program elements, comprising most of what we have called "advanced hardware DT&E," were reviewed by the appropriate mission or functional-area panels. This was done in conjunction with these panels' usual evaluation of the systems acquisitions proposed in their respective program areas at POM time.

These attempts have had little effect, however, since the views expressed by the Board Structure panels on RDT&E matters carry no

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[19] Chairman, Air Staff Board, in a letter to the RDT&E Panel, Air Staff Board, May 20, 1974. In addition to this panel, the Air Staff Board has chartered eleven others, as follows: Aerospace Defense; Airlift; Command, Control and Communications; Data Automation; Electronic Warfare Penetration; Reconnaissance/Intelligence; Simulator; Space; Strategic; Support; Tactical.

directive authority and have been given no corporate endorsement. Their advice provides only one of several types of opinion which RDT&E program planners from the functional staff can accept or reject as they deem appropriate. Thus, except for policy guidance conveyed to the formal review groups from SAFRD or the AF/RD on particular program elements, resource allocation within the RDT&E program is accomplished without assurance that it is in accord with a corporately endorsed set of priorities or preferences.

## SUMMARY ASSESSMENT

The central fault behind the lack of recognized, corporately endorsed resource-allocation priorities and the other shortcomings in the Air Force's long-range development planning is the inadequate state of strategic planning in the Air Staff. At present only a limited variety of long-range operational and functional goals are identified and the methods used are inappropriate considering the uncertainties inherent in periods beyond the FYDP period. Resource limitations possibly to be encountered in such a distant period are not assessed in terms of their potential impact on future programs. Top management's views on the relative importance of different capability alternatives and program directions for the period are not communicated regularly to technology program planners--even in response to recommendations for future-oriented policies contained in special studies. Among the practices followed by industry which offer interesting procedural contrasts warranting Air Force consideration are the maintenance of small corporate planning staffs and their regular assessment of long-range product-line goals.

Functional RDT&E program planning for the Air Force 6.2 and 6.3 development categories has improved in several encouraging ways since we first undertook this study. Assisted by the mission-area overview effort in Headquarters AFSC, systematic efforts to develop better program goals have been instituted for both the laboratory and system-oriented technology activities. Systematic comparison and evaluation of alternative technical approaches within respective mission areas

are being accomplished by AFSC for the 6.3 program elements. Alternative patterns of 6.2 and 6.3 resource allocation to accommodate different overall program levels have been examined in the course of recommending annual RDT&E program funding.

Some of these efforts are inhibited in what they can accomplish, however, by the inadequacies in Air Force strategic planning. Thus, AFSC's mission-area planning is attempting at once to (1) fill the gap left by the Air Force's inadequate strategic goal setting, and (2) provide technology planning guidance for the laboratories and product divisions. The latter function, translating Air Force preferences regarding future capability objectives into guidance directly useful in determining program goals for different levels of technology, clearly is an AFSC responsibility. Thus far circumstances have forced AFSC to devote most of its effort on Development Goals to drafting what are for the most part stand-ins for statements of corporate mission-capability objectives. But these goal statements are largely near-term--not long-range--in their orientation, and they have only limited utility as guidance for laboratory planning efforts. More generally useful for the Investment Strategy exercise and TPO efforts would be development goals compiled for various functional and technology areas, on which staff work has begun only recently. In terms of industrial practice, AFSC's DCS/Development Plans is now attempting to accomplish the planning functions of both the corporate planning staff and the R&D organizations.

This functional imbalance is likely to continue as long as the Air Staff and Air Force top management fail to provide for regular corporate assessments of the organization's long-term operational and functional goals and fail to provide its functional planners with clear statements of its long-term policy preferences. Corporately endorsed strategic goals and policies are needed so that all parties to the extremely complex RDT&E planning and programming process can act from common recognition of where the Air Force thinks it should be heading. As the process now operates, it is possible for each planning office, formal review group, and reviewing authority to follow its own perceptions (however valid they may believe them to be) of what that future direction should be.

# V. SUGGESTED IMPROVEMENTS

In suggesting how the Air Force might improve its overall process of planning for technology development, we are convinced that, at minimum, its relevant procedures should systematically provide that:

- The kinds of uncertainties appropriate to each stage of planning and development can be accounted for.
- Long-range Air Force capability needs can be identified and pursued.
- Technology initiatives can be encouraged and exploited.
- Technology and/or capability consequences of different program alternatives can be identified by planners and decisionmakers.

These are the conditions, or planning system criteria, which we have kept in mind in addressing possible improvements to the two major phases, strategic and functional, of our long-range development planning concept.

## STRATEGIC PLANNING IMPROVEMENTS

1. The Air Staff should implement and sustain a systematic strategic planning effort based on the studies and recommendations of a small corporate strategic planning staff located within the Chief of Staff's personal staff. The planning effort should provide long-range direction for its several functional planning activities by incorporating the review and approval or disapproval actions of Air Force top-level management. The latter should include the Air Force Board Structure.

The functions of the corporate strategic planning staff should include both the identification of long-range Air Force capability

goals and the assessment of expected future resource limitations.[1] Several methods are available for identifying future capability goals. One with promise is participatory polling; iterative rank-orderings of suggested capabilities within a mission area are obtained from a group of experts who are shown the results of and explanations for each of the group's previous judgments.[2] Another method, used in an AF/XOD study, derives capability objectives appropriate for each of five "warfare system" areas (space; mobility; combat information processing; global warfare; theater warfare) from a list of possible "future political-military demands." In the Development Goals project under the DCS/Development Plans, Headquarters AFSC, similarly useful methods are being employed. The methods of economic forecasting and macroeconomic analysis have proved appropriate for assessing resource availability. Planning staff reports to top management, based on the assessments, would properly include suggestions for preference ordering among the capability goals in view of expected resource limitations.

The important consideration is that the assessment be systematic and that careful treatment be given to the kinds of uncertainties inherent in both of these planning functions and in the extended time period involved. Studies and recommendations made by the special staff should preserve Air Force options to accommodate future deviations from the perceived trends in national policy, opponent capabilities, and resource diversity. This would involve casting off both the conceptual constraints of current mission areas and the expectation that new replacement systems should be developed for each area. It could involve also a conscious eschewing of the assumption that current command

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[1] The maintenance of small corporate planning staffs and their regular assessment of long-range product-line goals are two of the planning practices commonly followed by industrial firms and worthy of emulation by the Air Force.

[2] This method was first suggested in a briefing presented to the DCS/Research and Development and several Air Staff directors in June 1975. A summary assessment of one experiment conducted at Rand with participatory polling is provided in Appendix B.

arrangements and institutions will be perpetuated and a conscious acceptance of the possibility that alternatives might be better. For example, many factors considered in conjunction[3] raise questions as to why it should be necessary to maintain a distinction between strategic and tactical capabilities to strike fixed or slow-moving targets from bases in the CONUS. Why would it be necessary or prudent to provide separate follow-on aircraft systems for both so-called "missions"? Why not consider common, extended-range, long-endurance launching platforms designed to accommodate different combinations of special-purpose precision weapons and sensors assembled under central CONUS resource management? Such an alternative might look increasingly attractive if less-than-optimistic future funding assumptions were included in long-range planning. This is not to suggest that current missions and institutions necessarily be abandoned, but, rather, that other formulations and structures also be considered as serious alternatives.

The yearly output of capability-area analyses by the corporate planning staff need not be comprehensive. Although strategic planning estimates should be revised as data inputs and staff perceptions change, their long-range character makes it unnecessary that all of them be updated annually. It is more important that these products reflect imaginative and analytical thought processes than that they be produced in accordance with some predetermined timetable. Although preparation of an annual summary of the most up-to-date strategic planning estimates may provide a useful service to the functional Air Staff, a given year's effort might well be confined to a selected few capability areas. A different set could then be taken up as the first set was completed. Thus, the impact of each year's strategic planning on annual programming would be selective, perhaps affecting only a small proportion of the Air Force program submissions each year.

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[3]These factors include: rising aircraft production costs; increasing speeds; increasing range/payload capacities; aerial refueling improvements; unreliability of forward base availability; remotely piloted vehicles (RPV) and precision guided munitions (PGM) technology improvements.

Accordingly, analyses and recommendations of the strategic planning staff, as they are produced, should serve as inputs to the Extended Planning Annex (assuming that the DoD requirement for this reporting document continues), i.e., future capability goal recommendations of the corporate staff that gain approval by top Air Force management should be reflected in the EPA. By no means, however, should the EPA be regarded as an appropriate substitute for strategic planning. At best it is merely one of several communications devices by which particular long-range management decisions are made known to the Air Force functional staffs.

The corporate strategic planning staff should be in frequent communication with a wide variety of organizations, both within and outside the Air Force, e.g., the major operational commands, Air Force laboratories, the AF/XO staff, research centers, private industry, OSD, and Headquarters AFSC. It should obtain data and exchange ideas with these offices on a regular basis.

2. Air Force top management should make known in a formal statement its preferences regarding long-range capability goals and the distribution of future resources among different objects and levels of development effort.

In response to the goal assessments and economic analyses made by the corporate planning staff, top-level Air Force management should determine and, as appropriate, revise explicit long-range policies on the relative importance of future Air Force capabilities and the patterns of future resource distribution. Support for this function should be provided by such corporate policy-reviewing bodies as the Air Force Council, the Air Force Policy Council, and the Secretariat, Air Force Board Structure.

The force planning and RDT&E functional planning staffs, in particular, since they establish force goals and formulate technology programs that will lead eventually to the structuring of weapon and support systems, need more authoritative guidance on corporate long-range capability preferences. Explicit long-range policy statements

should be communicated to the functional staffs by top-level Air Force management (e.g., by the Air Force Council or Policy Council); these should reflect its view of the future and also encourage greater staff cognizance of long-range implications of current programs. Such statements would not be forecasts of future conditions and force structures. Rather, they need only relate different capability preference orderings to different potential patterns of resource availability. For example, if manpower and aircraft procurement costs are projected forward at recent inflation rates and USAF appropriations are assumed to be reduced significantly in constant dollars, a different ordering of capability preferences (particularly of those just below the very top-priority capabilities) might be preferred to that based on assumptions of level or of increased funding.

## FUNCTIONAL PLANNING IMPROVEMENTS

1. A clear division of responsibility on goal setting should be established between the proposed new corporate strategic planning staff and Headquarters AFSC's DCS/Development Planning. Whereas the Air Staff's corporate planning effort will identify long-range operational and functional capability goals, the AFSC effort to identify Development Goals should concentrate primarily on near-term goals, especially functional and technology goals that can be pursued directly in the 6.2 and 6.3 categories of the RDT&E program.

2. RDT&E program planners at both Headquarters AFSC and the Air Staff should distinguish more explicitly between those 6.2 and, particularly, 6.3 program elements which can be identified directly with operational or functional capabilities and those which cannot. More importantly, these offices should employ planning criteria appropriate to whichever of the respective types is represented by each program element.

Development tasks within those program elements which *can* be identified directly with specific capability goals should be planned so that progress toward these goals serves as a major factor in scheduling and programming these and related tasks. Development tasks within the *remaining* technology program elements should be planned with primary emphasis on the technical promise to be achieved and the technological opportunities to be exploited. For this kind of development activity, strategic goals and corporate preferences would contribute to general planning perspective and serve eventually as recognition factors to help determine the point at which successful technology development could be linked promisingly to useful capability development programs.

The studies of the strategic planning staff and the corporate preference statements issued by Air Force top management should be used by AFSC's development planners to guide them in their effort to achieve congruence with Air Force corporate goals for many of the 6.2 and 6.3 program elements. The AFSC staff effort to identify Development Goals should, however, also incorporate and encourage promising technology initiatives that cannot yet be linked directly to a particular capability goal.

> 3. Planning staffs at both Headquarters AFSC and the Air Staff and in the Air Force laboratories should assure that long-range corporate preferences about resource allocation are integrated routinely into RDT&E program planning. Control procedures implemented by the Air Staff R&D managers and by Headquarters AFSC should assure that planning actions over which they exercise authority include explicit attention to these long-range preferences.

In programming current RDT&E allocations in the context of the Defense PPBS, the Program Review Group and other participating Air Staff bodies should include long-range corporate preferences among their principal decision criteria. They should systematically compare different program elements and alternative technical approaches in order to assure

that high-preference capability areas are supported by a sufficient variety of technical approaches to hedge reasonably against uncertainties. Of course, resource limitations render this form of hedging practical for only the capability areas with high priority. For example, redundancy in the development of different strategic systems may be justified on the basis of the contribution strategic deterrence makes to the physical security of CONUS and on the basis of the anticipated impact of multiple development efforts on bargaining in the SALT context. However, no comparable high-priority considerations explain the currently high rate of redundancy in the development of navigation systems.

Functional technology program goals (TPOs) developed and pursued by the individual AFSC laboratories should reflect a balance--appropriate for the 6.2 technology areas to which each is dedicated--between long-range Air Force corporate preferences and the pursuit of promising technological opportunities. For example, the Air Force Weapons Laboratory TPOs would be expected to reflect corporate capability goals to a greater extent than those of Air Force Materials Laboratory. Headquarters AFSC, through its Investment Strategy analysis, should determine whether corporate high-preference capability areas are supported vigorously through alternative technical approaches and should assure that they are in its review of the laboratories' Research and Technology Plans. Eventually, as the Development Goals effort becomes more clearly oriented to functional and technology goals, a closer congruence can be established between the RDT&E program goals identified at Headquarters AFSC and those reflected in the laboratory plans.

## Appendix A

## AIR FORCE RDT&E PLANNING, PROGRAMMING, AND BUDGET CYCLE

When any fiscal year begins, most Air Force RDT&E activities embraced by that year's program have been under way for several years. These activities have been based on earlier initiating decisions and subsequent program-change decisions. Changes and new starts to be implemented during the new fiscal year are based on planning actions and decisions made during the preceding eighteen months. These decisions and the reviews and reports which support them make up the RDT&E planning, programming, and budget cycle.

### RELATIONSHIP TO DOD PLANNING

The Air Force cycle is paced by the DoD's formal Planning, Programming and Budget System (PPBS). The PPBS, first introduced by Secretary McNamara in 1961, is one of two historically rooted but essentially different processes in DoD planning. The other is the Joint Planning System which has been operated since the 1950s by the Joint Chiefs of Staff (JCS). An effort has been made to integrate the two systems, and descriptions of current DoD planning frequently include references to both.[1] However, in actual practice, the effort produces little more than an image of cooperation between the old and the new within the Department and a papering over of some fundamental differences in purpose and in approach.

The Joint Planning System consists of a series of estimates of functions to be performed, criteria to be met, and forces to be provided in support of the missions assigned to the unified and specified commanders by the President. It deals primarily with concepts and perceptions of "national security" and is rooted in interpretations of current and future "threats" to that security. It aims at advising the

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[1] See, for example, Chapter II of Richard Burt, *Defence Budgeting: The British and American Cases*, Adelphi Paper No. 112, International Institute for Strategic Studies, London, 1975.

national political authority on the force development strategy to achieve the national objectives, which it defines and elaborates upon, unconstrained by finite dollar limitations. Its currency is "professional military judgment" concerning the number and types of forces believed necessary to protect U.S. security interests.

In the language of our study, the Joint Planning System can be said to be representative neither of management control nor strategic planning. It deals to some extent with ongoing programs, e.g., base utilization; command arrangements and systems; security assistance to allies; military assistance advisory groups, etc. But, in many instances, its planning is not constrained explicitly by the budget and does not observe realistic limits regarding resource availability. Although it addresses future prospects and uncertainties, the methods the Joint Planning System uses in developing its planning products are not the tentative, searching analytical methods ideally associated with strategic planning.

The PPBS process, designed to facilitate the management of programs and resources, consists of a series of budget iterations coupled with appropriate forms of policy and programming guidance. The PPBS deals with current and near-term program actions and with resource commitments and expenditures; its currency is dollars, manpower, and items of equipment. It is a central feature of the DoD's management control system and thus provides a basic framework within which the functional planning of the various services and departmental agencies must take place.

This system is implemented each year with the Secretary's release in September of the Defense Policy and Planning Guidance (DPPG), providing broad near-term strategic policy guidance and fiscally unconstrained force planning guidance. It culminates in the budget decisions made by Congress eighteen or more months later. Congress has the final say on all Government spending and indeed may have a significant impact on RDT&E planning through its budget scrutiny, which extends to individual program elements and on selected programs reaches the project level. Because budget decisions by Congress have habitually spilled over into the fiscal year with which the budget

is concerned, reapportionment of appropriations has to be worked out by OSD and the services once the programs are under way. Thus, the cycle really approximates two calendar years.

Figure A-1 illustrates the major events comprising the PPBS and indicates the sequential relationship among the basic staff actions which comprise a single fiscal year's cycle. It also shows that in any given calendar year, different planning actions, pertaining to different fiscal years, occur simultaneously. We use here for illustrative purposes the planning cycle for Fiscal Year 1976, since that is the cycle we observed. Significant changes will occur in review and submission dates in subsequent years because of the Congressional Budget and Impoundment Control Act of 1974, but the basic elements and interactions of the Air Force process will likely remain the same.

To simplify, the DPPG is issued in the fall as a policy guide to OSD staffs, to functional planners in the DoD agencies and the services, and to force planners in the JCS. In one of the few points of interaction between the JCS and PPBS, national security objectives and policy elaborations in the DPPG are reflected in the Joint Strategic Objectives Paper (JSOP), Vol. II. Following issuance of the President's budget message to Congress in January, the policy guidance is reissued and along with it, (1) explicit fiscal guidance on spending constraints to be observed in preparing programming documents for the next five fiscal years, (2) materiel planning and consumption guidance for the same period, and (3) instructions for subsequent planning on programs of special significance at the time. All this is issued as the Secretary's Planning and Programming Guidance Memorandum (PPGM). Concurrent with preparation of the fiscal guidance, the services' respective portions of the FYDP are updated to reflect the latest White House budget policies. The updated FYDP provides estimates of new dollar levels to be allocated to each budget line-item (program element) for the next five fiscal years.

Publication of the PPGM kicks off preparation of the Program Objectives Memorandum (POM) by each of the services and the DoD agencies. Thus begins the first of the three major staff actions in the

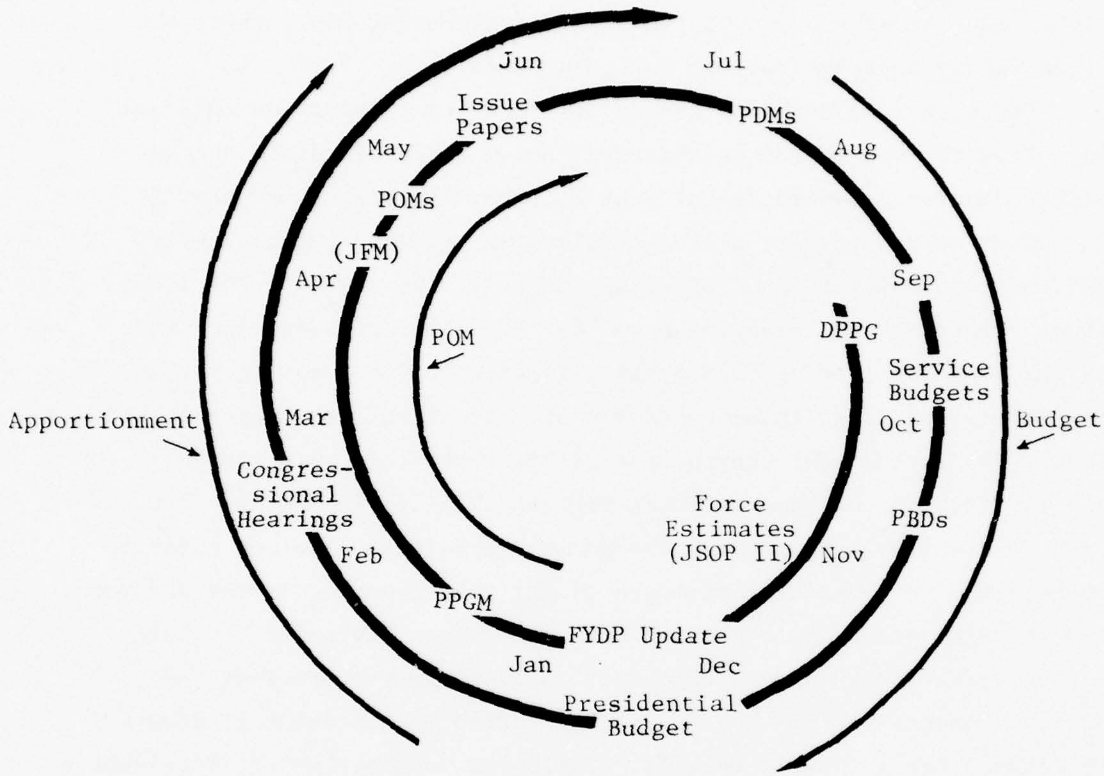


Fig. A-1--Defense planning, programming, and budgeting cycle, e.g., Fiscal Year 1976

PPBS to which Air Force RDT&E planning must relate. We describe the three major elements of the PPBS in turn: (1) the POM cycle, from January through May, during which the services make preliminary formulations of the five-year program and budget estimates, and submit them to OSD; (2) the budget cycle, from August to December, when programs and funding changes are hammered out in preparation for the submission of the OSD budget; and (3) the apportionment cycle, from January until Congress acts on the budget proposals (usually during the summer), when the necessary adjustments are made in resource allocations among the RDT&E programs.

POM CYCLE

The service response to the PPGM is the Program Objectives Memorandum (POM) issued by each of the services in May.[2] In it the Air Force (and each of the other services) makes its first formal contribution to the budget process for a particular fiscal year by estimating resource allocation for its many programs and laying out fully costed force structures for the five years ahead. The POM shows anticipated funding for particular programs and for each proposed budget line-item incorporated within a particular program. Thus, the proposed five-year annual funding levels for Air Force RDT&E (Program 6) are detailed for each program element in six program categories: the 6.1 through 6.5 categories and operational system development (coded by appropriate DoD program number). For example, operational development for the F-15 squadrons is coded 27130, from Program 2, General Purpose Forces.

Formulation of the Air Force POM begins with the Comptroller's estimates of a bogey sum of money to be allocated to each Air Force program during the POM fiscal year and subsequent program years.[3] Using the updated FYDP as a base line, the Director of Programs (AF/PRP), assisted by appropriate functional directorates in the Air Staff, must estimate how these overall sums are to be further allocated among the many individual program elements. With the single exception of RDT&E (Program 6), AF/PRP is responsible for developing POM increments for all Air Force programs. The Air Staff Board's Program Review Committee (PRC), a corporate body of division chiefs and colonels from 16 Air Staff offices and directorates, supervises and advises AF/PRP on the formulation of the POM; it is then submitted to the Air Staff

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[2]The unified commands and JCS also respond to the Secretary's guidance in the Joint Force Memorandum (JFM).

[3]Program 1 - Strategic Forces; Program 2 - General Purpose Forces; Program 3 - Intelligence and Communications; Program 4 - Airlift/Sealift; Program 5 - Guard and Reserve Forces; Program 6 - Research, Development, Test, and Evaluation; Program 7 - Central Supply Maintenance; Program 8 - Training, Medical, and Other General Personnel Activities; Program 9 - Administration and Associated Activities; Program 10 - Support of Other Nations.

Board and Air Force Council for review and subsequently is sent to the Chief and the Secretary. Usually the POM goes through several iterations before it is finally approved for submission to OSD.

To develop and defend the RDT&E program-element estimates for the POM is the responsibility of the Air Force's R&D community. Preliminary drafts of the RDT&E portion of the POM are developed simultaneously in the Air Staff's DCS/Research and Development (AF/RD) and at Headquarters AFSC, with frequent communication between review groups at both places. The program eventually agreed upon is submitted to the PRC for review as part of the initial POM iteration.

As a consequence of the PRC role in reviewing the Air Force POM, staff contributors are requested to effect a series of changes in their preferred programs to accommodate certain programs with a high corporate priority and yet stay within overall fiscal guidance limits. Assisting the PRC in identifying weak spots, imbalances, or excesses are twelve specialized panels, each with representation from the whole Air Staff.[4]

The POM for FY 1976-1980 underwent four iterations with respect to RDT&E. The principal reasons for RDT&E program modifications varied. Some changes resulted directly from PRC deliberations about force programs; others reflected DDR&E policy views, transmitted through SAFRD to the Secretary and the Chief. Of the four iterations required of the FY 1976-1980 POM estimates for RDT&E, two were occasioned by RDT&E bogey reductions, two merely reflected internal program reallocations.

During June and July OSD responds to the POMs in a series of issue papers sent to the Air Force (and to other services) for review and comment. Each paper defines the issues and alternatives and evaluates the capabilities and costs of the alternatives in terms of their ability

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[4]These panels, chartered individually and at various times since 1963 by the Air Staff Board, include: Aerospace Defense; Airlift; Command; Control and Communications; Data Automation; Electronic Warfare Penetration; Reconnaissance/Intelligence; RDT&E; Simulator; Space; Strategic; Support; Tactical.

to implement DoD policy. In late July, after the Air Staff has reviewed these issue papers and returned its comments, the OSD publishes tentative Program Decision Memorandums (PDMs) on the issues in question. If there are remaining issues unresolved, representatives of the Air Staff, Office of the Secretary, and OSD meet to thrash out the problems. In the case of RDT&E issues, both the Air Staff and AFSC participate in the issue reviews, and the SAFRD staff interacts frequently with DDR&E.

## BUDGET CYCLE

In August the final PDMs are issued to the services, and these signal the beginning of the DoD budget exercise. During August and September the Air Force R&D community formulates the RDT&E budget for the following fiscal year, using as planning bases the POM submission, PDMs, and guidance from the OSD and AF Comptrollers.

Changes in estimated resource allocations in preparation for submitting the RDT&E budget to the DoD are worked at both AF/RD and Headquarters AFSC. To back up any major program decision, AFSC must provide detailed cost data for the program in question from the laboratories or the product divisions, both of whom monitor contracts. Submissions from the field are important and are reviewed both in AFSC and in the Air Staff, because cost estimates and contract data may have changed since the April POM submission. OSD requires supporting justification for certain programs in order that it be available in case of Congressional inquiry. As next year's budget is being prepared, estimates for the FYDP are updated to reflect revisions in the budget with out-year implications. On October 1, the Air Force budget and the new FYDP are presented to OSD, and the review phase between OSD and the Air Force begins.

In October and November DDR&E holds a series of tri-service budget estimate reviews for each of the technology areas DDR&E considers in need of reassessment. These reviews scrutinize the technology base programs in light of defense needs, considering accomplishments, problem areas, gaps, and future impact of the work. They serve both as surveys of the technology area for OSD analyses and as preparation for subsequent Congressional inquiries.

At the same time, OSD/OMB budget reviews are in progress. Beginning in November, OSD publishes Program Budget Decisions (PBDs) authorizing changes in the Air Force budget estimates and FYDP. The Air Force either accepts the PBDs or reclamas, providing substantial data to enable OSD to reconsider the issue. OSD considers the reclamas and by the end of December releases the final PBDs. If there is disagreement on major issues, representatives of OSD, the Air Staff, and the Secretary of the Air Force, and occasionally of OMB, meet to resolve them. The DoD submits the budget in December, and in early January the President's Budget is published.

## APPORTIONMENT CYCLE

The Apportionment (and reapportionment) cycle begins with the submission of the DoD budget and ends eight to twelve months later when Congress has passed the budget legislation. When Congressional hearings are under way, Hq USAF must designate witnesses to testify and specialists to assist the witnesses. In case of inquiries on RDT&E proposals, all levels of the R&D community may be tapped for their expertise to support the budget request.

During the months that the hearings are in progress, apportionment of the RDT&E budget is considered at all levels of the R&D community. Adjustments of program-element and project support are made to bring them into line with budget changes made at DoD and White House levels and to accommodate changes in program status that have occurred since the formal reviews held in late summer.

When legislation is passed, AF/RD issues Program Management Directives instructing AFSC to carry out the budgeted RDT&E programs. When there is a delay in legislation beyond the start of the fiscal year, a regular occurrence in recent years, Congress must pass interim legislation (Continuing Resolution Authority) to keep the programs in progress. Reapportionment of estimated funds must be made to accommodate any changes which Congress directs in reaction to the RDT&E budget request. With legislative delays, RDT&E reapportionment can continue on into the fall months.

## Appendix B

## THE FORMULATION OF LONG-RANGE OPERATIONAL CAPABILITY GOALS[1]

The present report, as well as Ojdana and Weyant's recent models report,[2] argue that a principal element of long-range development planning is a set of long-range operational and functional capability goals that can be used both as a guide in the stimulation of technological ideas and as one basis for evaluating technical project alternatives.

Fully to satisfy the needs of an orderly, goal-oriented, long-range development planning process, the operational capability goals should have two key characteristics:

- They should be stated in terms of desired operational capability, not in terms of a specific system configuration or performance specification. In long-range planning, it is particularly important that the R&D community be challenged to suggest innovative ways of meeting operational objectives.
- The operational capability goals should be ordered in terms of relative importance. Without such a priority ranking, a statement of long-range operational capability objectives becomes simply another "wish list."

Numerous earlier studies have pointed out the need for a set of objectives with these characteristics. Why has it been so hard to satisfy this need? Let us examine in more detail the problems involved in establishing such long-range goals.

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[1]This appendix describes a Rand experiment in 1975-1976 using the participatory polling method of identifying future capability goals. The poll was devised and conducted by Giles Smith and Harold Sackman.

[2]E. S. Ojdana, Jr., and J. P. Weyant, *An Assessment of Selected Models Used for Evaluating Military R&D Projects*, The Rand Corporation, R-1847-PR, September 1976.

PROBLEMS OF GOAL SELECTION

A substantial body of literature exists on the process of defining goals and allocating relative priorities among tasks in a complex organization. In its simplest form, the prevailing theory has the following outline:

- A hierarchy of goals exists in any organization--a few overall objectives at the highest level and under these, subordinate goals. The overall objectives should relate to a series of more and more discrete subgoals as one descends through the various levels of the organization.
- At each level or tier in the hierarchical structure the individual goal elements in that tier can be assigned relative measures of importance.

An example, a hierarchy of Air Force objectives, is shown in Fig. B-1. Although, of course, an incomplete example, it does illustrate the growth of detail as one descends from "General Purpose Operations" through "Close Air Support" to a distinction between types of CAS targets. The numbers shown on the lefthand side of the figure suggest the approximate number of entries on each tier for a complete goal structure.

At the lower levels of the goal structure, where the mission objectives can be written in rather specific terms, it is usually not too difficult to achieve some consensus on the distribution of importance among the members of any one set (for example, comparison of importance between finding fixed versus finding movable targets in the close-air-support mission is something that many people would consider a not impossible task). As long as it stays within the confines of a specific operational task, the Air Force should be able to assign relative priorities among the various goals and then use the goals to evaluate quantitatively the potential benefit of each particular R&D project that could be expected to change the force capability on one or more of the specified missions.

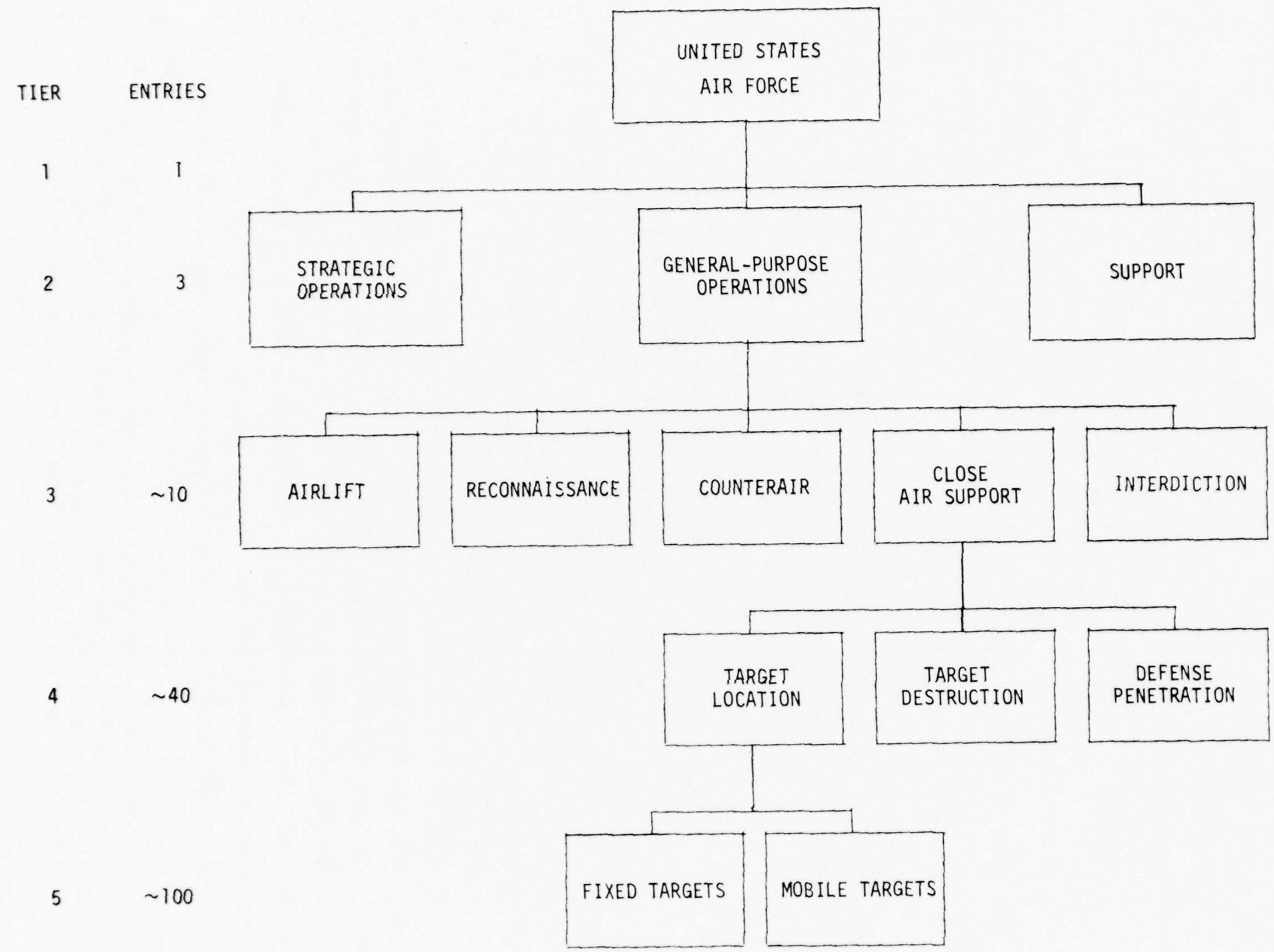


Fig. B-1--Mission-oriented goal structure of the U.S. Air Force

If one were to try to evaluate R&D projects analytically across the entire set of Advanced Hardware DT&E, he would encounter the problem of rationally allocating resources among the many different operational tasks involved in the whole spectrum of Air Force mission areas. This becomes particularly difficult at the higher tiers, because any reasonable breakdown of elements leads to entities that are not mutually exclusive, but are, in fact, highly interrelated. The analytical techniques and procedures now available to aid such a process do not work very well in such a situation.

This is an immensely complex problem, but the Air Force has never treated it in any explicit way and no official guidance on it is available. One would normally turn to the senior officers in Hq USAF to obtain guidance on a major policy topic like the distribution of relative importance among the various mission tasks. Without such guidance,[3] previous researchers who have tried to develop goal-oriented, analytical evaluation models for R&D planning have simply elected to develop the necessary priority or importance distribution themselves. This has proved unsatisfactory, in part because the resources available to staff members developing such procedures have been woefully inadequate for a task of such complexity, in part because they have not had adequate access to senior Air Force policy-makers.

Another reason why previous attempts to define relative priorities among major Air Force missions have been unsuccessful is that each task has a different set of parameters for measuring operational performance and no one set of parameters can be used for comparing value among all operational tasks. However, since our objective here is to help technology program planning, we can address the question of relative priorities among operational tasks rather narrowly. We can define a

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[3]Of course, implied guidance is available from the present distribution of budget among the various mission areas. However, that distribution depends in part on a number of other factors, including the technological opportunities available, and may change in the future. A simple extrapolation of present budget distribution is therefore inadequate.

single measure of importance and use it for assigning relative priorities among tasks at any tier of the goal structure. For our present purposes, we suggest the following definition of relative mission importance: *Importance is to be measured by how critical our need is to improve our capability at a particular operational task.*

The measure involves answers to both the following questions: (a) How critical is the need to perform, at some specified level of performance, a particular operational task, and (b) what is our present, or programmed, level of capability at that task? A particular mission task, for example, might be considered quite critical, but if our mission capability for the foreseeable future appears reasonably adequate, that mission area would not be assigned a high level of importance in terms of need for improvement.[4]

Determining the relative importance among a particular set of operational tasks is clearly a policy decision for top management, not something that can be calculated, and in fact, neither component of the above definition of relative mission importance is amenable to quantitative measurement. How then do we obtain such a statement of relative importance? The process becomes one of collecting, in an orderly way, the judgments of those officials best qualified to make the interpretations and policy decisions at the appropriate level in the decision hierarchy, as shown in Fig. B-1. Who are the people whose judgment should be sought? At the highest level of question aggregation (in Fig. B-1, the top two or three tiers, when the questions are oriented to parts of a mission area), the experts would probably be drawn principally from the relevant operational command. A significant point is that many knowledgeable people from throughout the Air Force can contribute meaningfully to the formulation of long-range operational capability goals.

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[4]Note that this definition is focused entirely on the operational need for some improvement in a particular mission capability. It does not consider the resources required to achieve the desired improvement (the matching of need and required resources takes place in a later evaluation of alternative technology development projects).

THE RAND EXPERIMENT

Some technique is obviously needed to collect in a systematic way the judgments of many knowledgeable people on a set of complex interrelated subjects which together would constitute a set of Air Force long-range force capability goals. A review of existing methods revealed that none is completely satisfactory for this purpose. Consequently, a new technique to meet the needs of this particular situation was formulated and subjected to a pilot test at Rand.

The technique was designed to meet the following criteria:

- Both questions and responses should be written. This was because of the large number of people involved and because questions and answers in writing tend to be more concise and thorough than those given orally.
- The process itself should help participants think about and formulate long-range capability objectives. Participants, therefore, should be aware of the views of others and, equally important, of the reasons for those views. Each person can then evaluate and judge the worth of competing ideas in a structured environment.

The procedure that evolved from these criteria was called "participatory polling." It involves the following steps:

First, a hierarchy of Air Force objectives is established, along the lines of the incomplete example shown in Fig. B-1. (The complete hierarchy, which would include all mission areas, is too lengthy to warrant being given in this appendix.)

Second, a set of questionnaires is prepared, each covering a portion of the overall mission hierarchy in the area of knowledge of a particular set of experts. The questionnaire would ask the participants to judge the relative priorities of competing mission objectives; it would also ask for the reason behind the judgments. The distinguishing feature of this process is that each judgment must be backed up by a set of reasons.

The results of the first-round questionnaire are collected, organized, and made available to the participants as part of a second-round questionnaire. The full frequency distribution of ratings by all participants, with a listing of reasons for the importance rating of each item, are included in the second-round package. The respondent is asked to become familiar with the arguments and rationale provided by others, he is then again to provide an importance rating for each item and for each rating give a set of reasons (revising his earlier reasons, if necessary). This process may cycle once again, although it is believed that no more than three rounds would be required.

Each participant will have the benefit of seeing whether the group leans toward consensus or disagreement and will see the reasons offered by the group. In addition, each participant will be able to determine the extent to which his anonymous opinions match those of others in the questionnaire sample.

This procedure, it should be noted, is deliberately designed to elicit (1) differences of opinion and (2) the reasons for such differences so as to facilitate the generation of a range of alternatives from which the policy-maker and planner may choose. That is to say, it is not a tool for generating consensus through group suggestion, nor does it put a premium on consensus, as does the Delphi technique. Rather, it is a balanced adversary process based on the feedback of the adversaries.

Rand performed a simple experiment to test participatory polling. Selected for the experiment was the close-air-support mission, an area neither too broad (as, for example, overall strategic planning would have been) nor too highly specialized (as would have been the case with advanced electronic-jamming countermeasures). The essential objective of the study was the initial exploratory application of participatory polling to long-range Air Force operational-capability goal identification for the close-air-support mission.

Basically, the scheme involved the logical partition of possible scenarios for the close-air-support mission into five categories, three of them environmental and two operational. The environmental variables

were type of war (NATO-WP versus U.S.-Third Area); visibility conditions (clear versus restricted); and type of penetration (manned versus non-manned, e.g., tactical fighter versus remotely piloted vehicle). The two operational variables were type of target (fixed versus mobile) and ways of coping with defenses (guided weapons versus guns). Each combination constituted a single questionnaire item. For example, the first item of the questionnaire was a close-air-support mission that required "coping with missiles, in a NATO war, on a clear day, with manned penetration."

Ten Rand staff members knowledgeable in close-air-support operation participated in the trial. The object of the first round was to obtain (1) relative importance ratings for each of the items from each expert in the panel and (2) the main reason for the importance rating given (the reasons were usually given in the form of a single phrase or sentence). There was a four-step importance scale: 0, unimportant; 1, marginally important; 2, important; 3, very important.

In the second round, approximately one month after the first, participants were given the same questionnaire with feedback. The feedback included descriptive statistics on the group's response to the first round (mean and standard deviation of importance ratings for each item, including the frequency distribution of ratings) and a list of three to five reasons for each item, including pro and con adversary positions, derived from first-round and open-end responses. The experts were asked to provide new ratings for each item based on all of the reasons presented and also to rank the importance of each of the listed reasons shown for each item. This procedure ensured that the ratings and reasons offered by others were examined and considered before second-round ratings were made. Thus, the second round provided item ratings and evaluations of first-round reasons.

PROCEDURAL OBSERVATIONS

Perhaps the most unusual characteristic of participatory polling is the requiring of written justifications of first-round ratings. Were any special difficulties encountered in obtaining and processing

these open-end responses? We were not completely successful in getting individual "reasons" for each item rating. Approximately half of all panelists' reasons were "dittoes" or repetitions of reasons offered earlier. In other words, in the typical first-round questionnaire about half of the items had reasons specifically associated with the particular rating, and half were direct replications of reasons given earlier, often with ditto marks. This "ditto phenomenon" is clearly a key procedural problem of participatory polling. Ideally, 100 percent of the responses would be unique.

Perhaps the most striking feature of the results are the quantitative and qualitative differences that emerged within this relatively small sample of experts working at Rand in virtually the same professional environment. In reporting their main insight from this study, the participants commented on the "diversity of opinion," the "divergence of views," and the "wide variation in response." This appreciation of the great range of expert opinion seems to suggest that perhaps the distinguishing characteristic of experts lies in their well-defined differences in values, assumptions, approaches, and personal judgments in current controversies in the domain of the inquiry. This interpretation supports a basic premise of participatory polling--the proper role of experts is to map out and explicate the range of alternatives in the domain of inquiry, in a balanced adversary setting. The focus is more on expert differences than on expert consensus, more on widening the range of thoughtful and explicated alternatives and policy choices than on narrowing choices and perhaps producing premature closure in contested areas.

An approximation to a balanced adversary procedure was achieved in presenting for review and evaluation in the second round essentially all distinct reasons for each item in the first round. A larger number of participants, perhaps 20 as opposed to the 10 used in this study, would have provided a larger number of reasons offered in support of first-round ratings. A larger pool of reasons, in turn, would permit more formal classification of reasons into pro and con positions to heighten the adversary effect (this was suggested by some panelists).

The adversary procedure was also "balanced" in two other key respects. First, all the experts were required to provide reasons for all their first-round ratings, not just the ones they chose to respond to. Second, the procedure treated all reasons equally; whether they conformed or diverged made no difference.

A key step in participatory polling is making available to all members of the panel the knowledge gained from first-round results in order to improve second-round judgments. To the extent desired, participants were able to use any or all of the first-round data--including mean and standard deviations, frequency distributions, and reasons--for their final evaluations. This exercise was only moderately successful in supplying optimal knowledge of the results of the first round of polling. Several panelists complained that the reasons were not spelled out in sufficient detail to make them convincing. The impact of more detailed justification of ratings was not tested, but open-end comments indicate that a greater level of detail in questionnaire items and in panelist reaction would probably have produced a greater impact on second-round opinion.

Some of the preceding comments apply to the adequacy of the group data base. A larger number of participants would have generated more extensive adversary arguments in contested areas. A more detailed set of reasons (e.g., a paragraph rather than a sentence for each item) would probably have produced more compelling reasons to modify ratings.

The group data base, at the end of two rounds, did meet certain practical requirements. Mean item ratings were reliably different from each other--the missile threat was seen as more critical than the gun threat, mobile targets such as troops and tanks were more important than fixed target--nonsurprising results. Differences between items were reliable, and test-retest reliability was high for quantitative measures. The composite quantitative and qualitative group data base for this study offers suggestive preliminary data illustrating Air Force mission requirements for close-air-support technology planning.

The panelists provided considerable feedback on particular test features, especially the rating procedures, and on the test as a whole. Virtually nothing escaped their critical evaluation. It is impossible

in a report of this limited scope to document all the comments received. Nonetheless, the instructions, procedures, forms, and spirit of this technique encouraged participants to act as experimenters as well as subjects, and the study benefited considerably from their participation. The participatory objective was successfully met in this initial study.

CONCLUSIONS FROM THE EXPERIMENT

The demonstration study described above is strictly illustrative and concerned only with the close-air-support mission. About a dozen other recognized Air Force operational mission areas affect long-range development planning, e.g., strategic offense, air defense, interdiction, development survellance, and intelligence. In addition, there are a number of functional-mission areas, e.g., command, control and communications, materiel handling, data processing, and training, to which technology development contributes. Follow-on studies could focus on individual areas in stepwise fashion to build up an inductive data base, or they could, as recommended by some of the panelists, provide comparative ratings for all Air Force mission areas as is the case with periodic budget review. The latter approach would provide a deductive data base. There are advantages and disadvantages to both approaches, but these will not be discussed here since our intent is primarily to point to possible future work.

Another desirable objective for follow-on Air Force studies is to use the technique to solicit expert opinion in relation to competing candidate projects, such as new weapons, new communications technology, and improved management systems. Our original idea was to obtain expert opinion for close-air-support mission requirements and then, with baseline mission requirements established, proceed to rate competing candidate Air Force projects on their cost effectiveness in achieving desired mission objectives. This approach could also be employed stepwise, on a mission-by-mission basis, or it could be implemented across all mission areas as described above. With either approach, the end result would be a systematic set of recommendations, with extensively evaluated reasons for such recommendations. They would include (1) preferred

mission objectives, and (2) preferred candidate R&D projects to pursue those objectives, and would provide a ranked set of alternatives for policy-makers to help determine relative priorities for long-range development planning in the Air Force.

A notable caveat should be mentioned for the above approaches. The expert panels should not consist entirely of one particular interest group, as were the Rand analysts in this demonstration. Various expert groupings should be tested for more balanced adversary results (e.g., operating command personnel, design and development specialists, senior policy-makers, and scientist-analysts). This recommendation came from our panelists and is supported by the research literature which shows clustering of opinion based on background. This type of safeguard is essential for controversial areas with major vested interests.

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# GLOSSARY

Advanced Hardware DT&E - Technology development activity that contributes to specific operational capabilities.

Advanced Development - Development projects in RDT&E category 6.3, directed toward developing hardware for experimental or operational testing. These include line items designed for test and experimentation, and subsystems being proved out for incorporation into a system program.

AFLC - Air Force Logistics Command.

AF/LGY - Director[ate] of Maintenance, Engineering, and Supply, Hq USAF.

AF/PR - Deputy Chief of Staff, Programs and Resources, Hq USAF.

AF/PRP - Director of Programs, Hq USAF.

AFR - Air Force Regulation.

AF/RD - Deputy Chief of Staff, Research and Development, Hq USAF.

AF/RDP - Director[ate] of Development and Acquisition, Hq. USAF.

AF/RDQ - Director[ate] of Operations Requirements, Hq USAF.

AF/RDR - Director[ate] of Reconnaissance and Electronic Warfare, HQ USAF.

AF/RDX - Director[ate] of Planning, Programming, and Analysis, Hq USAF.

AFSC - Air Force Systems Command.

AFSC Council - Commander's management advisory group in Headquarters AFSC, composed of headquarters general officers.

AF/XO - Deputy Chief of Staff, Plans and Operations, Hq USAF.

AF/XOD - Director[ate] of Doctrine, Concepts, and Objectives, Hq USAF.

AF/XOO - Director[ate] of Operations, Hq USAF.

AF/XOX - Director[ate] of Plans, Hq USAF.

Air Force Council - Advisory board to the Chief of Staff, composed of Vice Chief of Staff, Assistant Vice Chief of Staff, Comptroller, Inspector General, and all functional Deputy Chiefs of Staff.

Air Force Policy Council - Highest level Air Force policy committee within Air Force Board structure. It is chaired by the Secretary of the Air Force and has as members the Chief of Staff, the Deputy Chiefs of Staff, and the Assistant Secretaries.

Air Staff Board - Advisory board to Vice Chief of Staff on matters of programs, forces, and budgets. Members are: Director of Programs (chairman), Director of Budget, Director of Operational Requirements, Director of Personnel Planning, Director of Plans, Director of Logistics Plans and Programs, and Assistant Chief of Staff for Studies and Analysis.

Apportionment - Refers to that period of the PPBS cycle after the budget is submitted during which the department apportions the appropriation request specified by OMB. See Appendix A.

Budget - Refers to that part of the PPBS cycle from the time the program decisions (PDMs) are issued by OSD to the services until the DoD budget is submitted to OMB, a period of approximately five months. See Appendix A.

CONUS - Continental United States.

DCS - Deputy Chief of Staff.

DDR&E - Director of Defense Research and Engineering, OSD.

Development Goals - Goals identified by AFSC DCS/Development Plans for each Air Force mission area, based on analysis of threat, capabilities, capability objectives, deficiencies, programs under way, alternatives, and funding constraints.

DoD - Department of Defense

DDPG - Defense Policy and Planning Guidance. Guidance on the objectives and purposes of the DoD programs OSD issues to initiate the annual PPBS cycle.

D/S&T - Director of Science and Technology, Headquarters AFSC.

Engineering Development - Development programs in RDT&E category 6.4; engineered for service use but not yet approved for production or operation.

EPA - Extended Planning Annex to the POM.

Exploratory Development - Technology efforts, in RDT&E category 6.2, to resolve specific military problem areas and evaluate the feasibility and practicability of such solutions, short of major development projects.

FCRC - Federal Contract Research Center.

Functional Planning - setting current program goals for specific functional areas of an organization and determining how available resources can be allocated to assure that program goals will be met.

FY - Fiscal Year.

FYDP - Five-Year Defense Plan, base-line budgetary planning document for PPBS cycle, updated annually.

GAO - General Accounting Office.

Investment Strategy Exercise - AFSC D/S&T exercise analyzing the contribution of laboratory program elements in relation to specified Development Goals.

IOC - Initial operational capability, the date an operational unit equipped with a new system will enter the active force.

IR&D - Independent research and development, accomplished by private contractors.

JCS - Joint Chiefs of Staff.

JFM - Joint Force Memorandum.

Joint Planning System - Hierarchy and sequence of planning documents produced by the services, the unified military commands, and the Joint Staff, under guidance from the JCS.

JRDOD - Joint Research and Development Objectives Document.

JSOP - Joint Strategic Objective Paper.

Knowledge generation - R&D activity which cannot be related directly to a specific military operational capability.

Long-range Development Planning - Overall process by which an organization's long-range goals and development resource policies are determined and in pursuit of which its current technology programs are formulated.

Management Control - Planning and scheduling of current operations within the fiscal guidelines and resource allocation policies laid down by top-level organizational management.

MIRV - Multiple independently targetable reentry vehicle.

Mission Analyses - Studies sponsored by Headquarters AFSC to evaluate capability needs and system alternatives projected for selected missions.

Mission Area Overview - Continuing examination of each Air Force mission area in terms of threat, programmed capabilities, deficiencies, funding, system alternatives, and supporting technology by AFSC's DCS/Development Plans.

OCO - Operational capability objective.

OMB - Office of Management and Budget, Executive Office of the President.

OPR - Office of Primary Responsibility.

OSD - Office of the Secretary of Defense.

Overview - Formal review of proposed programs of all laboratories held at Headquarters AFSC annually before final formulation of each laboratory's plans.

PAR - Planning Activity Report, prepared by AFSC's DCS/Development Plans.

PBD - Program Budget Decision; OSD decisions assigning specific budget levels and programming to service programs.

PDM - Program Decision Memorandum; OSD instructions to services and Defense agencies on specific programming issues raised by their annual program proposals (POMs).

PEG - Program Evaluation Group of Headquarters AFSC.

PEM - Program element monitor.

PGM - Precision guided missile.

PMD - Program Management Directive; AF/RD instructions to carry out specific development programs.

POM - Program Objectives Memorandum; an annual proposal of programs to be carried out by each service and Defense agency at estimated levels of funding. Applies to early period of the PPBS cycle during which the documents are being formulated and reviewed. See Appendix A.

PPBS - Planning, Programming, and Budgeting System. See Appendix A.

PPGM - Planning and Programming Guidance Memorandum, issued by the Secretary of Defense to the services and Defense agencies, providing specific fiscal and constraining policy guidance to be followed in preparing their POMs.

PRC - Program Review Committee of the Air Staff Board.

PRG - Program Review Group of general officers in AF/RD.

Product Division - One of five AFSC organizations responsible for managing contracts for development work that is to be integrated into specific future systems.

Programming - Increment-by-increment planning estimates -- including the time-phasing of program stages and of expenditures -- for carrying out a specific job.

R&D - Research and Development.

R&T Plans - Research and Technology Plans, submitted annually to Headquarters AFSC by each laboratory. They indicate proposed 6.1 research and 6.3 development activity for the fiscal year.

RDT&E - Research, development, test, and evaluation.

RDT&E Category - In the DoD PPBS system, program 6; divided into the following five categories:

6.1 - Research
6.2 - Exploratory Development
6.3 - Advanced Development
6.4 - Engineering Development
6.5 - Management and Support.

ROC - Required Operational Capability.

RPV - Remotely piloted vehicle.

SAF/RD - Assistant Secretary of the Air Force for Research and Development.

Strategic Planning - Setting long-range goals, assessing future resource availability, and formulating policies for the overall organization.

Technical Review - Annual review of laboratory programs held at each laboratory.

TN - Technical Needs; formal statement of needed technology development, issued by AFSC product divisions.

TOA - Total Obligational Authority; financial requirements to support program for a given fiscal year.

TPG - Technology Planning Guide; prepared by Headquarters AFSC to assist Air Force laboratories plan their technology development activities.

TPO - Technology Planning Objectives; developed by each laboratory.

UE - Unit equipment, or numbers of stated equipment.